RICHARDSON'S

MECHANICAL DENTISTRY.

WARREN.

A

PRACTICAL TREATISE

ON

MECHANICAL DENTISTRY.

BY

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SIXTH EDITION.

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To

THE MEMORY OF THE LATE

JAMES TAYLOR, M.D., D.D.S.,

FORMERLY EMERITUS PROFESSOR OF THE INSTITUTES OF DENTAL SCIENCE
IN THE OHIO COLLEGE OF DENTAL SURGERY,

AS AN

ACKNOWLEDGMENT OF PROFESSIONAL EMINENCE
AND PRIVATE WORTH,

This Volume is gratefully inscribed,

BY

HIS FORMER PUPIL,

THE AUTHOR.

NOTE.

In preparing the sixth edition of this work, the editor's first effort has been to make it preëminently practical as a text-book for students, and a guide for young practitioners. Useless methods and obsolete theories have been eliminated, thus keeping the dimensions of the book convenient and compact. Much of the text has been re-written, notably the section on crown- and bridge-work—a volume in itself; it has also been newly illustrated, bringing the treatise fully up to the time of its publication.

The editor desires to acknowledge his indebtedness to the writings of Professors Wilbur F. Litch, C. J. Essig, L. P. Haskell, and Drs. George Evans, James W. White, Eben F. Flagg, John Allen, Theo. F. Chupein, and others.

Geo. W. Warren.

Philadelphia, October 20th, 1893.

PREFACE TO FIFTH EDITION.

The demand for a fifth edition of the present work, following closely upon the publication of the one immediately preceding, affords gratifying assurance of the profession's recognition of the treatise as a trustworthy exponent of the present status of prosthetic dentistry as illustrated in the practice and teachings of its representative members.

Not less obviously does it furnish proof of an increasing interest in a department of dental practice that has amply vindicated its claim to rank as a *conservative* branch of the healing art; a distinction due, in large part, to the introduction and growth of more or less perfected systems of root-crowning and bridge-dentures—systems involving processes of repair and methods of curative treatment that do not suffer by comparison with those practised at the chair in the important work of restoring to usefulness organs whose natural functions have been impaired or wholly subverted by the ravages of decay.

It is a suggestive fact, commended to the consideration of those who characterize prosthetic dentistry as essentially "mechanical," and who seek to disparage the professional and scientific qualifications necessary to success in this department, that the results achieved by the conservative methods alluded to have been reached *only* through a critical study of tooth-structure and function, a familiar acquaintance with pathological conditions associated with diseased teeth and implicated tissues, a comprehensive knowledge of the curative resources of dental therapeutics, a broad and intelligent apprehension of principles underlying mechanical devices, and a marvelous development of ingenuity and manipulative skill.

For obvious reasons, therefore, large space is given to the consideration of these systems of crown-replacement, the value

and importance of which command, at this time, general and deserved recognition. Subjected to the crucial tests of time, and amenable to the inexorable verdict of experience, many of them, doubtless, will at no distant day take their place "down among the dead men," while others, in obedience to the operation of laws that determine the "survival of the fittest," will live and take a fixed place among other humane devices that have proved lasting benefactions to mankind.

Without indicating specifically the supplemental contributions incorporated in this edition, it will be sufficient to state that the work has been materially enriched by the introduction of special methods of substitution, and various laboratory appliances, so conspicuously meritorious that they may properly be said to mark an era in the development of prosthetic practice.

JOSEPH RICHARDSON.

TERRE HAUTE, IND., *September, 1888.*

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ON

MECHANICAL DENTISTRY.

INTRODUCTION.

Before entering upon a detailed account of the agencies, processes and methods appertaining to the department of dental practice to which this work relates, some general reflections may not be inappropriate.

It is not the purpose of the author to unduly magnify the claims of prosthetic dentistry upon the regard and consideration of the profession. A just estimate of the nature of its requirements, and the momentous results contemplated in its practice, as well as the abundance and sufficiency of its resources in the accomplishment of its high and humane purposes, will, it is believed, amply vindicate its importance, its possibilities, and its eminent beneficence as a department of practical dentistry having intimate relation to the necessities of the unfortunate.

The untimely or premature loss of the natural teeth may be ascribed to a number of diverse causes. Multitudes are lost in consequence of abuse or neglect, or the dread of pain so commonly associated with the means employed in their preservation; many from unavoidable accident; and countless numbers are sacrificed through the incompetency and dishonesty of ignorant and unscrupulous parties who, in one guise or another, infest and prey upon communities.

Nor can we exclude from this list of causes another source of loss which, by implication, declares the impotence of the pro-

fession's curative resources in the absolute conservation of these important organs. Whatever sense of humiliation may attend the statement, it is nevertheless true that the highest attainable skill directed to the permanent preservation of the natural teeth must, in the very nature of things, often prove inadequate and abortive, for no proposition is more broadly or more generally recognized by intelligent practitioners than that conservative practice has its limitations growing out of conditions associated with individual organisms and environments wholly beyond the control of the operator. Whatever triumphs (and they are many and conspicuous) modern conservative dentistry may have achieved in the way of narrowing the field of prosthetic practice, the prophecy, born of hope, that the time will come when the utmost resources of human skill will, in respect of the teeth, be able to exempt mankind wholly from the penalties of transgressed law, is as Utopian and delusive as the faith that prophylactic or preventive medicine will ultimately eradicate every form of disease that at present afflicts mankind. They are alike the idle dreams of enthusiasts and visionaries. Physical infirmity, in one form or another, is the heritage of the race, and human skill, however well directed or conscientiously and intelligently administered, can do little more than assuage or mitigate the "pains and penalties" of the primal curse that rests upon all.

It is the peculiar and distinctive prerogative of prosthetic dentistry to devise and perfect means for the amelioration of the condition of those who, from whatever cause, have suffered one of the gravest forms of mutilation in the loss of organs so essential to the healthful performance of many important functions. In this special field of humane endeavor the highest order of qualification is imperatively demanded for the complete fulfilment of its diversified and complex requirements. No one can be said to be properly equipped for its duties who has not a more or less familiar acquaintance with such of the several branches of Physics and Natural Philosophy as relate in any manner to his special work, while an exact knowledge of the Anatomy, Physiology and Pathology of the tissues or structures in any way related to the substitute is absolutely indispensable. Added to such qualifications is the essential requirement of the

highest order of manipulative skill. But beyond all these qualifications, and supplementing them, is that art culture which is the crown and inspiration of all perfect work in every form of substitution, and without which the best results of mere handcraft are, in the main, but little better than libels and caricatures. In no other department of practical dentistry is the art instinct so strongly appealed to, or so imperiously demanded as a condition of the highest success. Dr. Eben M. Flagg, in an essay on Dental Art, very aptly says: "There is an element which enters into the conception and execution of every branch of our labor, and more or less forms part of every operation that we are called upon to make, be it surgical, operative or prosthetic. This element lightens our drudgery, enlarges our souls, gives individuality to our work, and brings satisfaction to ourselves that fully repays the time spent in fulfilling its requirements. It was born with our race, and has inseparably accompanied every movement that has brought comfort and happiness to man. It has contributed its share toward raising the physician from a mere 'bleeding, physicking, leeching' animal, to the position he occupies to-day, and has shown the mechanic and inventor that, if he would be great, he must be more than an artisan; he must be an artist. This element—the element of art—whenever it enters the field of human life, has for its function to finish and render attractive the hard labor that preceded it. Thus, we do not find it in its full manifestation except in those departments of labor which have attained scientific certainty."

Among the unnumbered millions of human beings who have peopled the earth since the dawn of time, it may be affirmed that no two have been created with faces exactly alike. There is the same aggregate of features, and a pervading general resemblance of one person to another, but there will be found as infinite a multiplication of distinct shades of facial expression as there are human faces, and each separate shade of expression characteristic of each one, and distinguishing him or her from all others, constitutes facial individuality. Each separate feature—as the eye, the nose, the mouth, the teeth, facial contour, complexion, temperament, etc.—contributes to this individuality, and no one special feature more, perhaps, than the teeth. There are few

more repulsive deformities than those inflicted by the loss of these organs, and none more fatal to the habitual and characteristic expression of the individual. It is the special mission, as it is the first and highest duty, of the dentist to preserve this individuality intact, and an equally imperative duty to restore it as perfectly as possible when impaired. To fulfil, in the most perfect manner possible, this most difficult of all the requirements of prosthetic practice implies an art culture that is competent to interpret the distinct play of features associated with individual physiognomies, to differentiate individual temperaments, and make available the sculptor's and painter's perceptions of the subtle harmonies of form and color.

To the failure or inability to properly comprehend the practical import or significance of individual characteristics, so far as they find expression in the teeth, and the consequent failure to conform our methods of replacement to the imperative requirements of art, may be fairly ascribed the deserved reproach into which prosthetic practice has fallen, and not, as is generally charged, to the employment of any particular material or methods concerned in the mechanical execution of the work.

There is no material classed among the so-called "cheap bases" that does not embody art possibilities far beyond what is being continually illustrated in general practice. Unquestionably they are not the best for the purpose, but they may be greatly enhanced in value, and rendered more deserving of professional favor, if utilized in conformity with the esthetic requirements imperatively demanded in all forms of substitution.

There is an ethical phase of this subject which must enter as an element into the profession's estimate of the suitableness of these inferior forms of replacement—a question of obligation and responsibility involving a problem the solution of which should be attempted without unreasonable prejudice or unjust discrimination so far as materials and methods are concerned. There are multitudes in every community who, though not in indigent circumstances, are unable to secure expensive services without great hardship, and other multitudes who perforce must suffer lasting harm and prolonged deformity on the same terms. Dentistry, like Medicine, is professedly a humane calling, and it would be

well to consider whether the afflicted have not just claims upon the profession's resources in providing them with inexpensive means of relief. Until the time comes when the necessities of this class can be supplied with wholly unobjectionable forms of substitution at a cost that is not oppressive, or that does not altogether deny relief, it will be well to cease indiscriminate condemnation of materials and methods which, when properly considered in relation to their yet undeveloped possibilities, are far from being unmixed evils. That there are radical and inherent objections to the use of vegetable plastics that do not attach to metallic bases is unquestionable, but it is equally true that the nature, behavior, and proper or scientific treatment of these substances have not been, until quite recently, well understood; that imperfect appliances have heretofore failed to develop their best qualities, and, above all, that there is a prevailing disregard or ignorance of all esthetic requirements in the uses to which they are applied. That the facility they afford for the ready construction of substitutes has attracted to the ranks of the profession a mercenary and unscrupulous class of operators, is as true as it is unfortunate. However powerless the profession may have been in the past to check this evil, the responsibility for its continuance in the future will rest largely with the profession itself. There is a reasonable assurance that the era of irresponsible quackery is fast passing away. The people of three-fourths of the States of the Union have, through their representatives, generously and confidingly relegated to the profession the power of providing a remedy for the evils of charlatanry, and have, under legal forms, designated our Colleges and Boards of Examiners as the proper custodians of the profession's honor and the people's interest. A faithful execution of the trust reposed in these bodies will go far to redeem prosthetic practice from the undeserved reproach brought upon it by a prostitution of its legitimate resources wholly unworthy of toleration and utterly destructive of all sense of professional self-respect.

PART FIRST.

METALS EMPLOYED IN DENTAL LABORATORY OPERATIONS, WITH PRELIMINARY OBSERVATIONS ON FUELS, AND THE VARIOUS APPLIANCES USED IN GENERATING AND APPLYING HEAT.

CHAPTER I.

FUELS.

It is essential that the mechanical operator should have some intelligent conception of the nature and properties of such combustible substances as are ordinarily used in the dental laboratory for the generation of heat. This, and a somewhat familiar acquaintance with approved appliances used in the application of heat and adapted to his peculiar needs, are indispensable requisites to the successful practise of the department of practical dentistry to which this work relates. Only such heat-producing substances as are deemed suitable for dental laboratory operations will be considered with any degree of particularity.

The general forms of fuel may be classified as *Liquid*, *Solid*, and *Gaseous*. They will be treated of, in more or less detail, under these general heads.

LIQUID FUELS.

In connection with lamps designed chiefly for soldering purposes and vulcanizing, the substances usually employed are alcohol, gasolene or kerosene. When alcohol is employed, the lamp shown in Fig. 1 is found very convenient and useful. Gasolene is used in connection with the Oxycarbon Forge (see page 47), while good kerosene, uncontaminated with naphtha, may be used with safety, and is, in many cases, a

valuable substitute for other combustible materials for general heating purposes, and is largely employed in connection with vulcanite and celluloid work by those unable to command the ordinary illuminating gas.

SOLID FUELS.

Under this head are comprehended such combustible substances as are used for fires or draft furnaces, as wood, charcoal, bituminous and anthracite coal, and coke. For baking or muffle furnaces used in the construction of continuous-gum work and other allied processes, anthracite and coke are esteemed the most suitable on account of the high temperatures attainable in their use, and the persistent or prolonged heat consequent on the comparatively slow waste of substance in the process of combustion.

Wood, except when charred, is wholly unsuited for laboratory work.

Bituminous, or **pit coals**, are generally unfit for the uses required of fuel by the dentist, on account of the excessive carbonaceous residue accompanying their combustion, and are, therefore, seldom used except when reduced to that form of mineral charcoal known as coke.

As charcoal, coke, or a mixture of the two, and anthracite coal are the heat-producing substances chiefly used in the processes of the dental laboratory requiring the employment of solid fuels, they will be more particularly described.

Charcoal is the solid residuum of the destructive distillation of wood. It is obtained by igniting wood, and then excluding it from the air while burning; the volatile products are thus driven off, while the carbon remains. The chemical composition of the ordinary charcoal of commerce is given in the following table, in which it will be seen to consist principally of carbon, combined with certain volatile constituents, a considerable percentage of absorbed water, and but little ash :—

Carbon,	70	Nitrogen,	1
Hydrogen,	5	Ash,	2
Oxygen,	11	Hygroscopic moisture,	11

During the process of charring, the volatile constituents—

hydrogen, oxygen and nitrogen—are, in a large measure, driven off, but no temperature that can be commanded, and no time, however prolonged, will wholly expel them.

Charcoal is insipid and inodorous, is a poor conductor of heat and a good conductor of electricity, is insoluble in water, is attacked by nitric acid with difficulty, and is but little affected by the other acids or by alkalies. Its carbon constituent is exceedingly refractory to heat, and, if secluded in a retort, will neither fuse nor volatilize under the highest temperature that can be produced. This latter property of carbon, in connection with that of its comparative non-conduction of heat, makes it a valuable ingredient in the construction of supports used in soldering, represented in the carbon block and cylinder (Figs. 27, 28), and in the devices (Figs. 50, 51) combining crucible and ingot mold. Charcoal retains the organic structure of the wood from which it was produced, except when prepared at a very high temperature, when it becomes a black, shining, porous mass, resembling fossil coal, with a considerable increase in density and without a trace of organic structure.

When it is desired to maintain a high heat in a small compass, the charcoal best adapted to the purpose is that obtained from what is termed *hard* wood, as the beech, the oak, the alder, the birch, the elm, etc. A cubic foot of charcoal derived from these woods weighs, upon an average, from twelve to thirteen pounds, while a similar bulk obtained from *soft* wood, as the fir, the different kinds of pine, the larch, the linden, the willow and the poplar, averages only from eight to nine pounds.* There is, therefore, economy in the use of the former when purchased in bulk ; and of this class the beech-wood charcoal is the best on account of its greater specific gravity. Charcoals derived from the hard woods possess the additional advantage of generating a more equable and enduring temperature, and are, therefore, better adapted to operations in the laboratory requiring a prolonged heat. The more heavy charcoals require a stronger draft than those of a lighter character, as a more generous supply of oxygen is necessary to their perfect combustion. Charcoal should

* Ure.

be kept as dry as practicable, since it readily absorbs moisture from the atmosphere, by which its calorific energy is materially impaired.

Coke.—This substance is a carbonaceous product obtained from bituminous coal that has been exposed to ignition for some time, excluded from the contact of air, the volatile constituents of the coal, like those of wood, having been driven off by the heat. There are two different varieties of this mineral charcoal, namely, gas coke, obtained from the retorts of gas works after the gases have been separated; and oven coke, which is made in ovens or pits, and which is considered by manufacturers as the only true coke, gas coke being merely cinder. There is a marked difference in the appearance of the two kinds of coke, the principal part of that obtained from gas houses being of a dull, iron-black color, very spongy and friable, is more rapidly consumed in the process of combustion, and produces less heat than the harder and more compact variety. The best coke for heating purposes is the oven or pit coke, which has a steel-gray color, with somewhat metallic luster, is compact in structure, and splits into pieces having a longitudinal fracture. Whenever it can be procured, the latter should always be preferred in connection with the use of the baking or muffle furnaces employed in the fabrication of continuous-gum work, porcelain teeth, etc. Until the more recent substitution of anthracite, the former was exclusively employed for these purposes, and is in every way suitable in the production of high and persistent temperatures. It is sometimes used combined with charcoal, but, when fairly ignited, gives an augmented and more lasting heat when used alone.

Coke does not readily ignite, and at first generally requires the admixture of charcoal to effect its combustion; it also requires a strong draft to burn it, but when thoroughly ignited it produces an intense and persistent heat. As before stated, it is the principal fuel used in baking mineral teeth, porcelain blocks, and the silicious compounds employed in the construction of continuous-gum work.

Professor Piggot, in his remarks on the comparative value of fuels, observes: "Practically, for the purpose of the chemist,

the best fuel is charcoal or coke, or a mixture of the two. The ash of charcoal being infusible, it passes through the bars of the grate as a white powder. Should potash, however, be in large excess, it corrodes the bricks by forming with them a silicate of potash, which runs down the walls and chokes the bars. In small quantities this action is beneficial, as it furnishes a protective varnish, and unites the bricks and lutes by forming a sort of cement, which intimately combines with them.

"Coke contains a very variable amount of ash, which is composed chiefly of oxid of iron and clay. The latter is not fusible by itself, but may soften. When pure it forms a harmless slag, which injures neither the furnace nor the crucibles. Usually, however, the oxid of iron predominates. In this case the ash is very injurious, for it is reduced to a protoxid, which is not only fusible, but powerfully corrosive to all argillaceous matters, so that both the crucibles and furnaces suffer."*

Anthracite.—Anthracite is the most condensed variety of mineral coal, containing the largest proportion of carbon and the smallest quantity of volatile matter. With the exception of the diamond, it is the purest form of carbon in its natural state. The best specimens contain 95 per cent. carbon, but the average production of the purest beds of this coal will not exceed 90 per cent., and generally not more than 80 to 87 per cent. carbon. The volatile matter in the dense, hard varieties, is almost exclusively water and earthy impurities, but in common varieties the volatile portion consists of water, hydrogen, oxygen, and nitrogen, while the ash or incombustible matter contains oxid of iron, iron pyrites, silica, alumina, magnesia, lime, etc. Anthracite which contains only 80 per cent. carbon, with 20 per cent. water and incombustible matter, is the lowest grade of commercial coal, and of little value as fuel.

The general features and fractures of hard anthracite are peculiar and noticeable to the common observer. They are massive, hard, dense, amorphous or conchoidal in fracture, with fine, sharp edges when broken, and a rich satin or an iron-black sub-metallic luster. With some local exceptions the softer

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* "Dental Chemistry and Metallurgy," p. 274.

varieties, both red- and white-ash (by which name the Pennsylvania anthracite coals are generally known), are less massive, hard and dense, more regular and cubical in fracture, and, exclusive of the upper red-ash beds, less rich and lustrous.

Anthracite coals, in greater or less abundance, and of varying qualities, are found in several of the States and territories of the Union, namely, in Pennsylvania, Massachusetts, Rhode Island, Virgina, Arkansas, Oregon, and in New Mexico and Sonora. Of the European anthracite fields, exclusive of those in Wales, England, the most prolific and largely developed are those in France, while others of more limited production are found in Spain, Portugal, Germany, Austria and Norway. Anthracite also exists in Persia, India, China and in South America. The most prominent anthracite fields of the world, however, are those of Pennsylvania and South Wales, which produce nine-tenths of the quantity used. The developed coal fields of the world embrace an area of about 350,000 square miles, of which over 300,000 are in the United States, exclusive of lignite. About 2000 square miles of this entire area contain anthracite, of which half is in the United States, including the somewhat doubtful New England coal fields. The entire coal production of the world in 1871 was between 225 and 250 million tons, of which England produced 110 millions and the United States 41 millions. About 20 millions of the entire amount was anthracite, of which 15 million tons were produced in Pennsylvania, and the remainder in South Wales, France and other countries.

The first authentic account which we find of the use of anthracite in the United States was in 1768–69, when it was used by two blacksmiths from Connecticut, named Gore. It did not, on account of the difficulty of making it burn, come into use for domestic purposes till 1808, when Judge Fell succeeded in burning "stone coal" in a grate of his own construction. This was probably the first successful use of anthracite for general purposes in the world. So imperfectly were the properties of this fuel understood, and so little known of its proper management, that four years later, Col. Shoemaker, who had disposed of several loads of it to parties in Philadelphia who were unable to burn it, was arrested, upon a writ obtained from

the city authorities, as an impostor and swindler, who had sold them rocks for coal.

Prof. H. D. Rogers explains the formation of anthracite by supposing it to be the result of altered bituminous coal metamorphosed by intense heat, and, of course, by heat induced subsequent to the formation of the bituminous beds; and he further explains the escape of the volatile portion of the latter as gas through cracks and openings caused by the plication of the anthracite strata. This plication follows closely the general type of the paleozoic rocks, which are intensely crushed and folded near the contact of their edges with the igneous or granitic rocks, and much less plicated and distorted in a western direction. This theory, though natural and ingenious, is controverted by others who contend that anthracite is not a metamorphosis of bituminous coal, but as much a normal creation as the bituminous variety itself, from a combination of its constituents under superior heat, however the original elements were produced.

The particular mineral fuel under consideration has been treated of here somewhat at length, for the reason that it is being more generally employed of late years by the dentist, not only for refining and general heating purposes, but more especially in those important processes of the dental laboratory in which more or less refractory silicious substances requiring a high, uniform and prolonged heat, are employed in compounding body and gum enamels, in baking mineral teeth, and in the construction of continuous-gum work. For the latter especially, it is preferred by many to coke, in connection with solid fuel furnáces.

Owing to the difficulty of igniting anthracite, it is customary to mix with it at first about an equal quantity of charcoal. Its proper combustion after ignition, when burned alone, requires a strong draft, which is ordinarily attainable in use of the ordinary draft or muffle furnace properly connected with a suitable flue. Under conditions that insure more or less complete combustion, the chief of which is a generous supply of oxygen, anthracite will yield a higher temperature than any other kind of solid fuel. The blast furnace is, therefore, best adapted to

this end, though for all ordinary purposes requiring heat in the dental laboratory the ordinary chimney draft will be sufficient. To recapitulate somewhat, it may be said, not only in reference to anthracite, but to the other solid fuels mentioned, that in order that the greatest amount of heat may be generated, it is necessary that the conditions essential to their most perfect combustion should be strictly observed; these, as before stated, have reference mainly to an unobstructed circulation of air in order that oxygen may be freely supplied to them. To this end the furnace should be kept clean, the bars of the grate unbroken, and a good draft obtained. The condition in which the fuel is applied will also modify the results. Thus, for example, if the lumps are too large, they will absorb heat, and caloric will be lost; if too small, they will be too rapidly consumed. It is essential, also, to have the fuel as free as possible from dust and dirt, as these fine particles in any considerable quantities obstruct the draft, and prevent a thorough ignition of the mass. Coke, especially, should be preserved clean, and should be broken into fragments not larger than an inch or an inch and a half in diameter, and, as nearly as possible, in the form of blocks or cubes, as these leave more open spaces for the free circulation of air.

GASEOUS FUEL.

Illuminating Gas.—The ordinary illuminating gas, derived from the destructive distillation of bituminous coals, is a form of fuel that, of late years, is rapidly supplanting the use of the liquid and solid varieties for heating purposes in the dental laboratory. The introduction of gas, for the uses indicated, marks an era in prosthetic practice, so far as the application of heat for metallurgic purposes is concerned, in which inventive genius has been industriously and successfully employed in devising and perfecting appliances designed to obviate entirely the necessity of employing other forms of fuel heretofore used, and which are, in many respects, inconvenient and objectionable. So fruitful have been these later devices in meeting the necessities of the dental metallurgist, and so reasonably certain is it that more extended experiments in the construction of furnaces adapted to this mode of producing heat will, in the near future, meet all the requirements of ceramic

art, as applied to dental prosthetics, that it may be confidently predicted that all solid fuels for these purposes will be wholly banished from the laboratory wherever gas can be commanded for the generation of heat. The latter, intermixed with atmospheric air in proper proportions, and used in connection with burners and furnaces of suitable construction, is, in all essential respects, preferable, since it is comparatively free from dirt and smoke, and is capable of producing a rapid, equable and intense heat, which is completely under the control of the operator as respects duration and the degree of temperature required for any given operation.

Natural gas has, until recently, been obtained only in very limited quantities. There are many localities where combustible gases have long been known to issue from the earth. Gas has been used in China for centuries, conveyed in bamboo tubes from fissures in salt mines, in excavations from 1200 to 1600 feet in depth. Near the Caspian Sea, in Asia, there are several so-called eternal fires caused by gas issuing from the soil. In parts of New York it issues from bituminous limestone interspersed among the slates and sandstones of the Portage group; but the most prolific sources of natural gas are in the coal regions of western Pennsylvania, where rapidly multiplying wells are yielding almost unlimited supplies of this light and heat-producing combustible, and which, in some of the larger cities, is being utilized not only for illuminating purposes, but for fuel in many of the manufacturing establishments.

The chief supplies of illuminating gas, however, are derived from the destructive distillation of various grades of bituminous coal, and, to a more limited extent, from wood, peat, resin, petroleum, oils and fats, and from water and coke. As the gas used in the dental laboratory for the generation of heat is the common house illuminating gas obtained from coal, this variety only will be treated of in this place.

Bituminous coals, such as English cannel and boghead coals, Ohio cannel, and the coking coals of Pennsylvania, Maryland and Virginia, are commonly used in the manufacture of illuminating gas. When bituminous coal is heated to redness in the presence of air, it is principally converted into gases which unite

with oxygen; but if air is excluded, as when the coal is confined in retorts, the gaseous products, unable to unite with oxygen, may be collected in receivers and burned in tubes. The products of the destructive distillation of bituminous coal consists of a great number of gases, liquids and solids, which may be conveniently included under the following heads, according to an analysis by Bunsen:—

Coke,	68.93	Olefiant gas,	0.78
Tar,	12.23	Sulphuretted hydrogen,	0.75
Water,	7.40	Hydrogen,	0.50
Marsh gas,	7.04	Ammonia,	0.17
Carbonic oxid,	1.13	Nitrogen,	0.03
Carbonic acid,	1.07		

The illuminating power of the gas may be regarded as depending principally upon the amount of olefiant gas (heavy carburetted hydrogen) which it contains, the bulk of other gases being carriers rather than light-producers. The olefiant gas is separated by ignition into marsh gas (light carburetted hydrogen) and carbon, the solid particles of which become incandescent and emit white light, which is observed in the luminous cone of a gas flame, and which has the same constitution as that of a candle. The luminosity of a gas flame depends both upon the percentage of heavy hydrocarbons it contains and the amount of atmospheric air or oxygen mixed with it. With the admixture of air or oxygen, the illuminating power of the gas is diminished, while there is at the same time increased evolution of heat. This fact is of interest and value to the dentist, since it underlies the construction of all the modern forms of heating appliances made on the principle of the Bunsen burner, which provides for intermingling currents of atmospheric air and gas. Oxygen thus applied to the gas jet, and combining with the carbon at the moment of ignition, greatly augments the heat of the flame, while the latter becomes almost non-luminous.

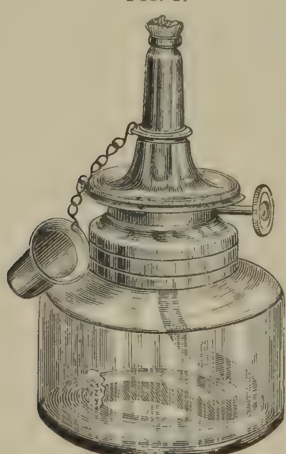
Oxy-Hydrogen Gas.—A combination of nitrous oxid and illuminating gas has been used of late in the dental laboratory with highly satisfactory results, forming practically an oxy-hydrogen flame of great heating power. (See Dr. Knapp's oxy-hydrogen blowpipe, page 48.)

CHAPTER II.

APPLIANCES USED IN THE GENERATION AND APPLICATION OF HEAT.

The modes of generating heat, and the appliances used in its application to the various mechanical processes of the dental laboratory, will require more or less detailed descriptions of the several agencies employed for these purposes. These relate to *Lamps*, *Burners*, *Blowpipes*, *Supports*, *Crucibles*, and *Furnaces*. As full a description of these several appliances will be given as

FIG. 1.



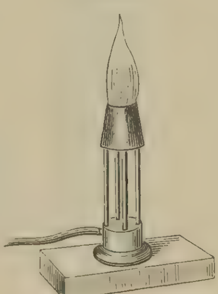
is compatible with the scope of the present work. The agencies employed in the generation and application of heat alluded to under the head of lamps, burners, supports, and blowpipes, are such as are used chiefly in soldering, one of the most important and not always the least difficult processes of the dental laboratory, while furnaces are largely used for melting and refining purposes, compounding body and gum materials, baking

porcelain teeth, and in constructing continuous-gum work. Heaters are adapted to a variety of purposes requiring moderate temperatures, as melting some of the more fusible metals, warming water, heating plaster molds preparatory to packing plastic substances, etc.

Lamps.—For all the minor operations of the laboratory requiring the application of moderate degrees of heat in the use of either the mouth or the simpler forms of bellows blowpipe, an ordinary alcohol lamp or the gasolene furnace described on page 62 will be found serviceable and efficient. When, however, gas can be commanded, it is preferable to the oils or alcohol for heat-producing purposes, on account of its greater convenience and freedom from accident.

Burners.—The ordinary gas flame is unsuitable for soldering or other operations, by reason of the carbonaceous residue with which it is constantly charged. This source of uncleanliness may be gotten rid of by an admixture of air with the gas flame. This intermingling of gas and air currents for the purpose of augmenting the heat of the gas flame, and of rendering it in other respects more suitable for general metallurgic purposes, was first practised by Bunsen, a distinguished German chemist, by means of a simple contrivance represented in Fig. 2. All modern heat producing appliances usually denominated Bunsen burners utilize the same principle in the generation of heat, and differ only in mechanical construction from Bunsen's original device.

FIG. 2.

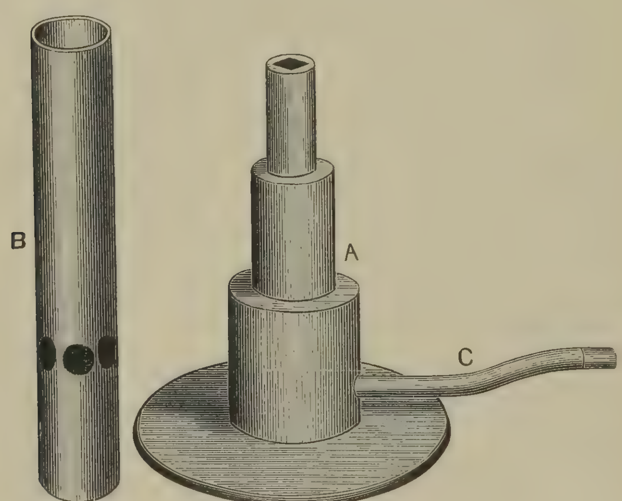


A very simple contrivance embracing the principle of the Bunsen burner, is shown in Fig. 3. A represents an ordinary gas burner attached to a circular cast-iron base, with a stationary tube, C, entering near the bottom, for the supply of gas. B is a hollow cylinder of sheet brass or copper, the lower half of which is perforated with small holes for the admission of air. This is placed on the burner, the perforated end fitting over the central portion, leaving something of a space above, between the burner and cylinder, for the free circulation of air. The cylinder, when

in place, should extend two inches or more above the tip of the burner. The gas is supplied through a flexible rubber tube connected with the stem of the burner, and connected at the other end with any ordinary gas burner conveniently located in the laboratory. For soldering small pieces, and for many other purposes requiring a ready and manageable heat, the author has used this simple appliance, with great satisfaction, for many years.

To obtain a flame of greater volume than is possible with the burner just described, a Bunsen burner may be constructed in

FIG. 3.



the manner described by Prof. Essig in his work on Dental Metallurgy.

This consists in attaching to the base of an ordinary Bunsen burner (Fig. 4), such as is sold at the dental depots, a piece of brass tubing six inches in length by one and a quarter inches in diameter. Over the top of this, in order to properly spread the flame, a piece of fine wire gauze is fastened, by means of a ring of sheet brass one-quarter of an inch in width. Gas is supplied in the same manner described in connection with Fig. 3. This contrivance, while it fully meets the general requirements

of the operator, is especially adapted to drying and heating up large pieces before soldering, and for melting alloys of gold and silver in considerable quantities.

Fig. 5.

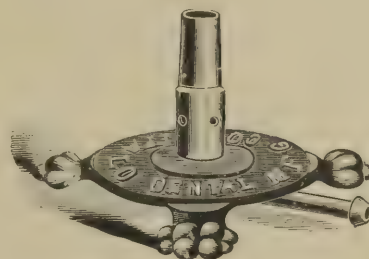


Fig. 4.

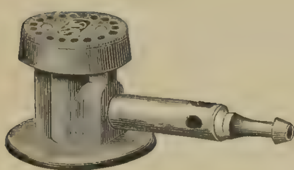
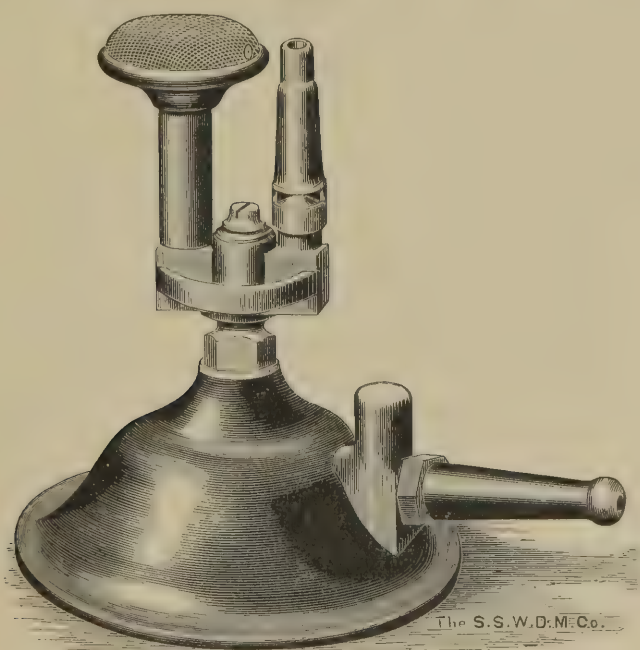


Fig. 6.



A compact and convenient burner for general laboratory uses is represented in Fig. 5. It is especially useful in "waxing up" a base plate, heating water, vulcanizing, and other minor operations requiring a moderate and easily-graduated heat.

Another heating apparatus of recent introduction, designed, in part, for soldering with the use of blowpipes, is represented in Fig. 6. It is called the "Duplex Burner," and will be found very convenient for laboratory use. In addition to the usual Bunsen burner, a large flame for the blowpipe can be had by rotating the upper portion upon the base. A small jet, when once lighted, ignites either flame, so that it is always ready for use.

There are many other varieties of these heating appliances constructed on the principle of the Bunsen burner, but it is not deemed essential to further multiply them in this place.

BLOWPIPES.

Following the descriptions of lamps and burners given in the preceding pages, it would seem appropriate to consider next the various forms of blowpipes used in the application of the heat produced by means of the appliances named.

Various modifications in the form of the blowpipe have been introduced from time to time, and are named according to the means used to produce the blast, as—*mouth*, *bellows*, *self-acting* or *spirit*, and the Gasolene or "Oxy-carbon" blowpipe.

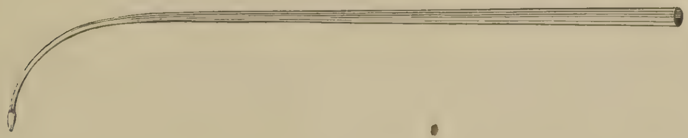
In addition to the varieties mentioned, there are others, used in producing extreme degrees of heat, as the "oxygen blowpipe," with which the flame is blown with a jet of oxygen; and another, with which the two gases, oxygen and hydrogen, are burned, called the "oxy-hydrogen blowpipe." The latter is capable of producing a heat that immediately fuses the most refractory substances, as quartz, flint, rock-crystal, plumbago, etc. With it gold is volatilized and iron rapidly consumed when placed in the flame; while platinum, next to iridium the most infusible of all known metals, has been melted in quantities exceeding one hundred ounces by means of this powerful instrument. As, however, these blowpipes are, for the most part, of no special practical utility in the dental laboratory, reference will be had only to the one recently introduced by Dr. Knapp, of New Orleans, La. Nor is it deemed necessary to embrace descriptions of spirit blowpipes, as they have fallen, of late years, almost wholly into disuse.

MOUTH BLOWPIPE.

This instrument has been long in use, is simple in its form and construction, and, for general use in the application of moderate degrees of heat, is both convenient and economical. Those accustomed to its use are enabled to produce a continuous blast of considerable force, and soon acquire the facility of regulating the heat produced with equal if not greater precision than can be readily attained in any other way.

The most simple form of the mouth blowpipe is shown in Fig. 7. It consists, usually, of a plain tube of brass, larger at the end applied to the mouth, and tapering gradually to a point at its other extremity, the latter being curved and tipped at the point with a conical-shaped, raised margin, to protect it from the action

FIG. 7.



of the flame; the caliber of the instrument terminates here in a very small orifice. The point of the instrument, as well as that part of it received into the mouth, is sometimes plated with a less oxidizable metal than brass, as silver or platinum. The stem is generally from twelve to twenty inches in length, and the mouth extremity from one-half to three-fourths of an inch in diameter.

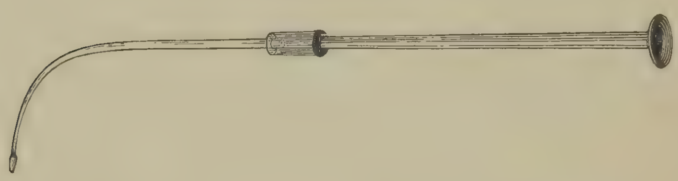
In operations requiring protracted blowing, a somewhat different form of the instrument will be required, owing to the accumulation of moisture within the tube, which, being forcibly expelled from the orifice, spurts upon whatever is being heated and interrupts the blast; also, on account of the fatigue, which in process of time renders the muscles of the mouth and face engaged in the act to a great extent powerless.

The difficulties mentioned may be obviated, in a great measure, by applying the form of blowpipe represented in Fig. 8. To the mouth extremity is attached a circular concave flange or collar which receives and supports the lips. To the shaft, near

its curved extremity, is adjusted either a spherical or cylindrical chamber which collects and retains the moisture as it forms within the pipe. By allowing that part of the tube connected with the curved end to pass part way into the chamber, a basin is formed at the depending portion of the latter, which, by collecting the fluids, will effectually prevent them from overflowing and passing into the tube beyond.

Thomas Fletcher, of Warrington, England, has introduced

FIG. 8.



modifications in the construction of mouth blowpipes which are unquestionably improvements upon the simpler forms just described. One form, styled the hot-blast mouth blowpipe, is shown in Fig. 9. The improvement in this instance consists in coiling the air-tube into a light spiral over the point of the jet. This coil takes up the heat which would otherwise be wasted, and utilizes it by heating the air in its passage. It is claimed that with the use of this instrument much higher temperatures are

FIG. 9.

reached than is possible with the ordinary blowpipe, and that with the same amount of blowing nearly double the work is accomplished, while, if a high heat is not required, the labor of blowing is reduced in proportion. A similar form of instrument (Fig. 10) is made with a hard-rubber mouth-piece.

Another form of mouth blowpipe by the same inventor is exhibited in Fig. 11. It will be seen to be wholly unlike any mouth blowpipe yet devised, and admits of great latitude of

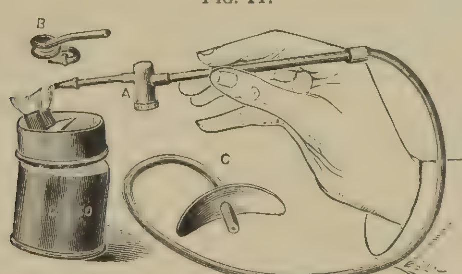
movements in the application of heat. This form of the mouthpiece is especially adapted to continued blowing without strain on the lips, while the opening is well under the control of the tongue. The blowpipe proper is held as a pencil, the chamber collecting condensed moisture and preventing the passage of heat up to the end. The instrument can be readily changed from a cold- to a hot-blast blowpipe by substituting the coil (B) for the plain jet or tip.

FIG. 10.

There are other allied forms of the mouth blowpipe, but as they are constructed more especially for chemical examinations or analyses, and as they possess no advantages, for dental purposes, over those already mentioned, a description of them is not necessary.

Mechanism Involved in the Act of Producing a Continuous Blast with the Mouth Blowpipe.—As a steady, continuous current of air from the blowpipe is preferable to the interrupted jet in all those operations where it is desired to produce a steadily augmenting heat, the following remarks explanatory of the method of producing it are subjoined, in the belief that they will render easier a process not always readily acquired.

FIG. 11.



"The tongue must be applied to the roof of the mouth, so as

to interrupt the communication between the passage of the nostrils and the mouth. The operator now fills his mouth with air, which is to be passed through the pipe by compressing the muscles of the cheeks, while he breathes through the nostrils and uses the palate as a valve. When the mouth becomes nearly empty, it is replenished by the lungs in an instant, while the tongue is momentarily withdrawn from the roof of the mouth. The stream of air can be continued for a long time without the least fatigue or injury to the lungs.

"The easier way for the student to accustom himself to the use of the blowpipe, is first to learn to fill the mouth with air, and while the lips are kept firmly closed to breathe freely through the nostrils. Having effected this much, he may introduce the mouth-piece of the blowpipe between his lips. By inflating the cheeks and breathing through the nostrils, he will soon learn to use the instrument without the least fatigue. The air is forced through the tube, against the flame, by the action of the muscles of the cheeks, while he continues to breathe without interruption, through the nostrils. Having become acquainted with this process, it only requires some practice to produce a steady jet of flame. A defect in the nature of the combustible used, as bad oil, such as fish oil, or oil thickened by long standing or by dirt, dirty cotton wick, or an untrimmed one, or a dirty wick holder, or a want of steadiness of the hand that holds the blowpipe, will prevent a steady jet of flame. But, frequently, the fault lies in the orifice of the jet, as too small a hole or its partial stoppage by dirt, which will prevent a steady jet of air and lead to difficulty. With a good blowpipe, the air projects the entire flame, forming a horizontal, blue cone of flame, which converges to a point at about an inch from the wick, with a larger, longer, and more luminous flame enveloping it, and terminating at a point beyond that of the blue flame." *

BELLOWS BLOWPIPE.

There are many processes of the dental laboratory requiring the application of a higher temperature than is obtainable with

* "The Practical Use of the Blowpipe."—*Anon.*

the mouth blowpipe. A more powerful and persistent air blast is readily produced by a bellows or foot blower, used commonly in connection with a burner of suitable form attached to the common gas jet, by means of which the gas is furnished with the oxygen required for its combustion in a state of intimate mixture.

A simple and compact form of bellows or foot blower is shown in Fig. 12. The pressure obtainable with this instrument is continuous, equable, and completely under the control of the operator, but the current may be greatly increased in power after the rubber disk is distended until forced against the net.

A bellows of similar construction, but with the position of the

Fig. 12.

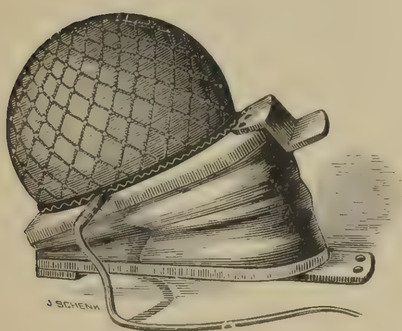
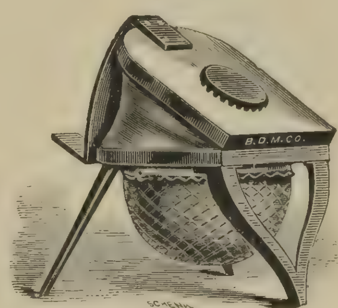


Fig. 13.



blower reversed, is shown in Fig. 13. By this arrangement the disk is less liable to injury, while it prevents the valve from picking up dirt from the floor.

A contrivance essentially different in its construction from the ordinary bellows employed to produce the air jet is shown in Fig. 14, and is known as the "Burgess Mechanical Blowpipe." When in use, the air is drawn into a cylinder and condensed in an air chamber, ready to be used in large or small quantities at the will of the operator, by a rapid or slow movement of the treadle. When operating, place the entire foot upon the treadle, so that an easy rocking motion is obtained; by pressing the toe downward, air is drawn into the cylinder, and in reversing the motion it is driven into the air chamber above. The pipe outlet

is much smaller than in the mouth blowpipe, to enable a pressure to be obtained, which is increased or diminished by a quick or slow motion of the treadle. The air chamber is easily filled, and when so a constant supply of pure air is at the control of the operator.

The blowpipes used in connection with the bellows are of various forms. Fig. 15 represents one form of apparatus employed in the application of the air blast to the gas flame.

A movable gas jet attached to two short arms of an ordinary

FIG. 14.

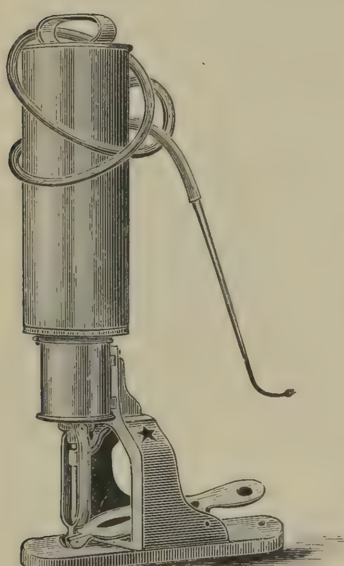


FIG. 15.

gas pipe is made to receive within it the blowpipe point connected with the rubber tube, the air tube terminating a little within the open mouth of the gas jet; it is thus a tube within a tube, with a space between them for the admission and passage of gas. The gas, being admitted by turning the tap connected with the gas pipe, is ignited, when the current of air from the bellows will strike the center of the flame and project it upon whatever is to be heated. The connected portions of the air and gas jets are so attached to the main pipe as to admit of an up-

ward and downward motion, while the volume of gas and air is readily graduated by the stop-cocks attached to the air and gas tubes.

A bellows blowpipe, constructed on similar principles, but admitting of greater latitude of movements, is exhibited in Fig. 16. As will be readily observed, it is capable of being adjusted in any desired position. The jet tube may be raised or lowered to any height and turned in any direction. A touch will direct the flame on any point while the blowpipe stands in the same position on the table; there being no necessity for raising, lowering, or adjusting work before it.

Macomber's gas blowpipe, Fig. 17, differs somewhat in con-

FIG. 16.

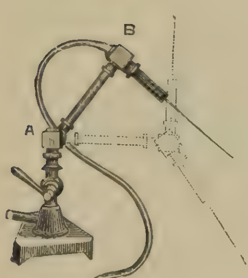
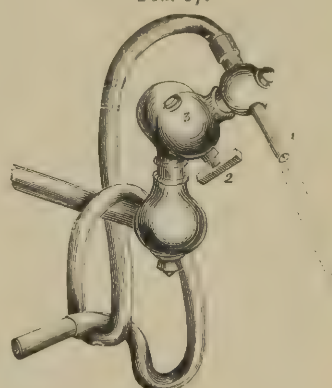


FIG. 17.



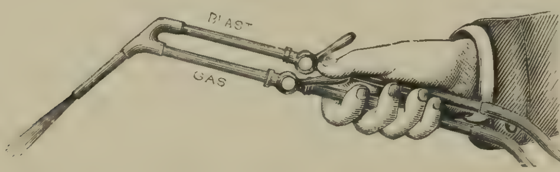
struction from the latter, its capability of adjustment being regulated by a ball-and-socket attachment which imparts to it, at the will of the operator, a latitude of movement or adjustment of the blowpipe point that is practically without limit. The direction of the point, 1, is regulated by the joint, 3, and the supply of gas controlled by the stop-cock, 2. The air is supplied by the bellows through the flexible tube.

A very convenient, manageable and effective instrument for many purposes requiring the application of heat in the dental laboratory is the hand blowpipe shown in Fig. 18. It is capable of producing very high degrees of heat, but the intensity of the latter may be graduated at the will of the operator, as the stop-

cocks, which are both under perfect control of the thumb of the hand which holds the blowpipe, regulate the supply of gas and control the volume of air. The air jet is one-eighth inch bore, and requires a supply from a bellows.

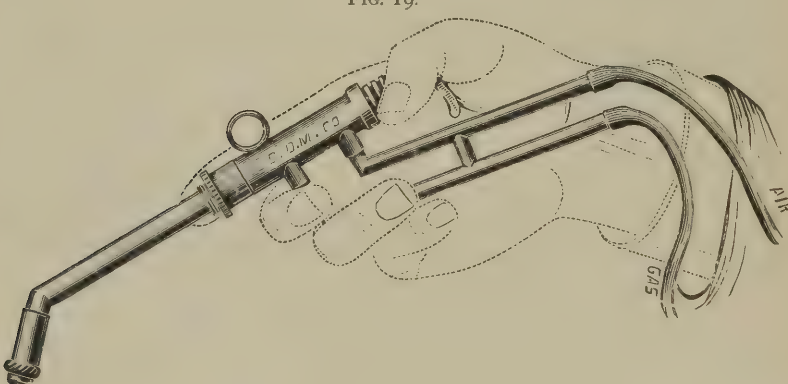
Fig. 19 represents an improved pattern of the Fletcher

FIG. 18.



Automaton, designed especially for crown- and bridge-work. It is made of smaller tubing than the No. 6 A or B Automaton, the end being bent at an angle to give greater facility in directing the flame. The adjustable nozzle is screwed on and off, instead of operating by a slip-joint, as in other patterns of the automaton blowpipe. Its length is increased, removing the hand farther from

FIG. 19.



the heat. The supply of gas and air is controlled by a longitudinal movement of the tube, instead of a rotative one. A spring opposes the movement of the hand, and a slight variation of pressure upon the end-piece, when it is held as shown, is sufficient to give either a pointed jet or a full-sized brush flame at pleasure. An

improved tip is used on the air jet, and the small blue-pointed reducing flame is very easily and perfectly produced.

The gas passage does not close entirely, but allows the passage of enough gas to prevent the flame from going out when the blowpipe is not in use. It can be hung up by the ring shown on its body, when it is desirable to get it out of the hand.

FIG. 20.

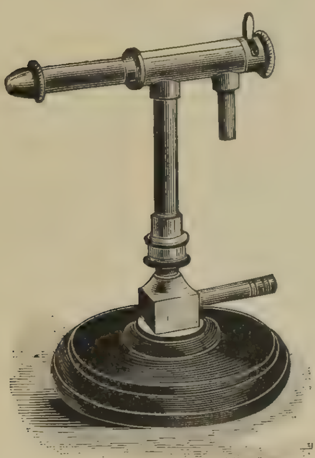
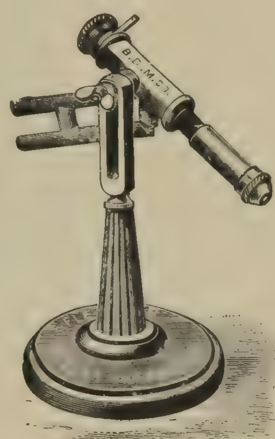


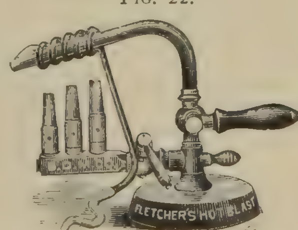
FIG. 21.



Two very convenient forms ot the Fletcher automatic blowpipe are shown in Figs. 20 and 21. The latter, which is mounted on a ball joint, is adjustable at the will of the operator.

In cases requiring a heat of sufficient intensity to readily fuse pure gold, as in the construction of continuous-gum work, where this metal in its unalloyed form is used to unite the teeth and plate, the hot-blast blowpipe contrived by Mr. Fletcher, exhibited in Fig. 22, will be found efficient for the purpose. The air pipe, as will be seen, is coiled around the gas pipe, and both are heated by three small Bunsen burners, the gas supply to which is regulated by a separate stopcock, as shown in the figure. The air blast is obtained with the bellows or foot blower connected

FIG. 22.



with the blowpipe by means of a flexible rubber tube. It is claimed that the heat-producing power of this simple device is but little inferior to that of the oxy-hydrogen blowpipe, and may be useful, therefore, in the treatment or management of highly refractory metals or substances not readily acted upon by the highest heat of the ordinary forms of bellows blowpipe.

The several forms of bellows blowpipe illustrated in these pages are complete and efficient, and admirably adapted to the necessities of the mechanical operator. In most instances, the jet may be elevated or depressed at will, while the force of the air current and the volume of the gas flame can as readily be increased or diminished. The operator is thus enabled, with the greatest ease, to produce a heat adapted to the most delicate operations, or to instantly change it to a heat so intense that pure gold in considerable quantities is almost immediately fused in the flame. They are, therefore, well adapted to all operations in the laboratory, but will be found of special utility in the construction of work requiring pure gold as a solder.

THE GASOLENE OR OXY-CARBON BLOWPIPE.

Where illuminating gas is not available, the oxy-carbon forge or blowpipe will be found most useful. It gives a high, steady, smokeless, and nearly odorless blast, and at the same time does not require either the bellows attachment or lung power. It is less expensive than gas or alcohol, is safe, portable, durable and is simple to control and handle. It can be changed instantly from an intense heat to a feeble flame, or the reverse. The entire forge is only about twelve inches high, having a base nine inches in diameter, and can be run all day with one-half gallon of 74° deodorized gasolene (see page 62) without any attention, excepting a few minutes' use with the rubber bulb to keep up the necessary air pressure. This forge is illustrated in Figs. 23, 24, and 25.

It can be used for vulcanizing, heating investments, soldering, melting metals, annealing plates, for waxing, or any purpose for which heat may be required in the laboratory.

FIG. 23.

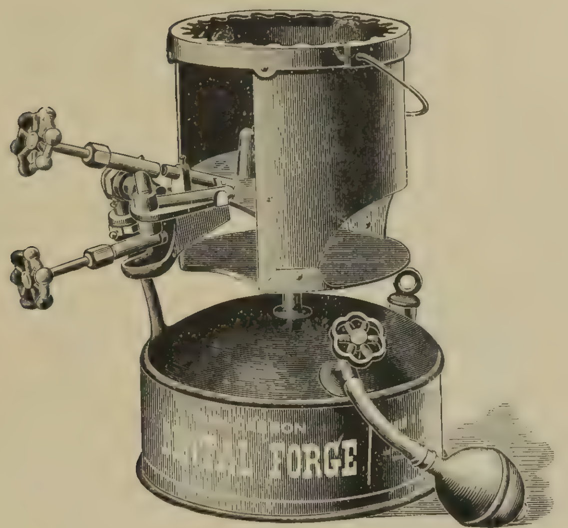
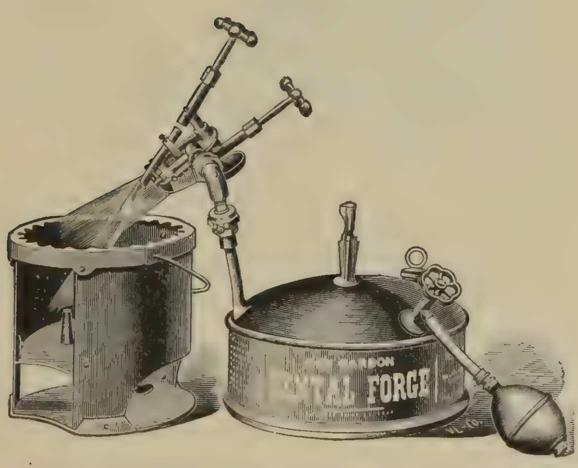


FIG. 24.



OXY-HYDROGEN BLOWPIPE.

No dental laboratory appliance for heating purposes has ever been devised that has attracted so much attention, or elicited such cordial and unreserved praise by expert manipulators, as that invented by Dr. J. Rollo Knapp, of New Orleans, La., and shown in Fig. 26.

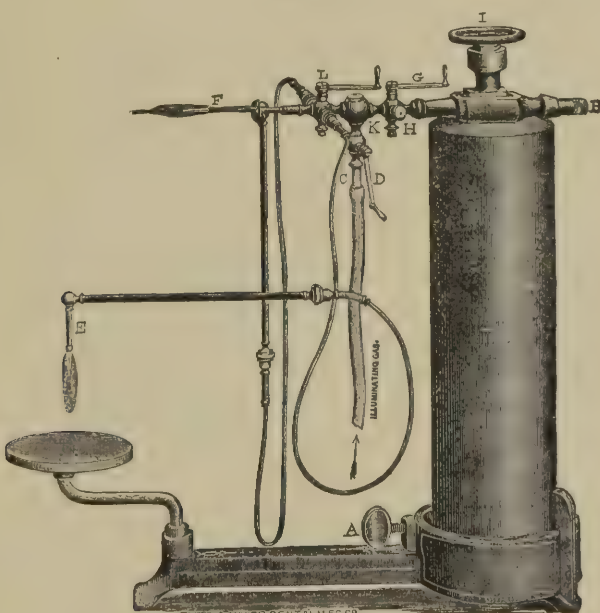
It is described as being to all intents and purposes an oxy-hydrogen blowpipe divested of the cumbersome paraphernalia usually accompanying the latter, and reduced to a practical size

FIG. 25.

and shape for soldering operations. It is essentially an apparatus for securing the consumption of hydrogen in a highly oxygenated atmosphere, the resulting flame being second in intensity only to that of the oxy-hydrogen blowpipe proper. It will melt gold or its alloys in quantities suited to its capacity almost instantly, without other exertion on the part of the operator than the adjustment of a couple of small levers. It is economical of time and materials, and not the least notable of its good qualities is its cleanliness. Its inventor has been accustomed to do all his soldering of crown- and bridge-work without leaving the operat-

ing room. It can be used wherever illuminating gas is available. Any of the soldering operations of the laboratory, from the largest piece of bridge-work to the most delicate joining of the narrowest bands or finest wires, are accomplished with equal facility. With illuminating gas of good quality and sufficient pressure, a pennyweight of twenty-carat gold can be melted in thirty seconds. When the investment is large, it must first be heated by other means.

FIG. 26.



The apparatus consists of the blowpipe attachments, connected to the yoke of a nitrous oxid gas cylinder, the cylinder being set upright, and secured by a thumb-screw on one end of an iron base or stand, at the other end of which is pivoted a table, upon which to rest the work. The blowpipe proper is a continuation of the outlet tube of the gas cylinder. A lever-valve, G, regulates the supply of nitrous oxid. Just beyond this valve is the mixing chamber K, to which the illuminating gas is conducted from the gas bracket by means of rubber tubing, entering

the bottom of the chamber through the valved tube, C. The lever, D, controls the supply. The mixing chamber is provided with a gauze screen to prevent the flame from being drawn into the supply tubes. Immediately beyond the mixing chamber the pipe is branched to afford two flames of different sizes, E and F, which can be used independently of each other or both together. The valve-lever, L, regulates the flame in both. For greater convenience in manipulation the pipe-nozzles are connected with the branched pipe by rubber tubing. From the body of the valve L an arm extends, at the end of which is a small scalloped disk as a holder for the flame-nozzles when not in use. In the illustration one of the nozzles is shown in the holder, the other being directed to the revolving table.

SUPPORTS.

There are many processes in the dental laboratory for which it is necessary to provide a suitable holder or support, as in melting small quantities of gold and silver, and in all the varied operations requiring the use of solder.

For melting or soldering small pieces, a variety of simple devices, easily and economically constructed, may be used, among which are the following:—

Charcoal, either alone or combined with other non-conducting substances, is very commonly employed, and being combustible, adds materially to the heat of the blowpipe flame. A convenient support of this kind may be made by selecting a fair-sized block of compact, close-grained charcoal, derived from some of the hard woods, such as oak or beech, and investing it in plaster one-half or three-fourths of an inch thick, one end or side being left open and made concave, to receive whatever is being heated. Or a plaster cup, two or three inches deep and three or four inches in diameter, may be used, its interior being filled with a mixture of plaster, sand, asbestos, and pulverized charcoal. Coke, encased in the same manner as charcoal, may be substituted for the latter, and has the merit of being more lasting, but in all other respects is inferior for the purpose. Supports for the uses under consideration are also sometimes made of pumice-stone.

Prof. Essig * says: "Platner's 'Manual of Qualitative and Quantitative Analysis with the Blowpipe,' page 15, gives a method of artificially preparing good, solid supports of charcoal which might be found of value in the dental laboratory. It consists of mixing charcoal dust (which must not be too finely ground) with starch paste. The latter is prepared by combining one part of starch with six parts of boiling water. These are stirred in an earthen pot until all the meal is converted into paste. This paste is rubbed in a porcelain mortar, with frequent additions of charcoal dust, until the mass becomes too tough for further admixture, when enough of the coal dust is kneaded in by the hands to render the whole mass stiff and plastic. From this the desired forms of blowpipe coals can be made, allowed to dry gradually and thoroughly, and then heated to redness in a cov-

Fig. 27.

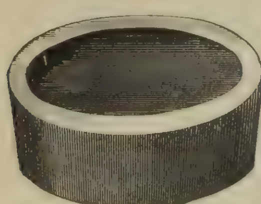


Fig. 28.

ered vessel, so as to char the starch paste. The charring may be regarded as complete when the evolution of the gases from the mass ceases, or when it has been heated to a dull redness. Coals thus formed are of the proper firmness, and ring like ordinary good charcoal when thrown on the table."

Manufactured supports composed of asbestos and carbon, very convenient and durable, may be obtained at the dental depots. Fig. 27 represents a carbon block designed for melting and soldering, and Fig. 28 a carbon cylinder used chiefly for soldering small pieces.

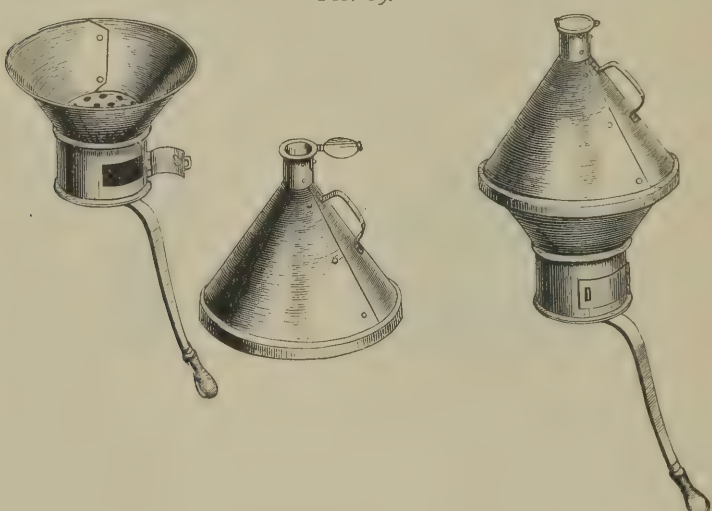
For soldering purposes exclusively, especially in uniting teeth to a metallic base, either of the following means of support for the invested piece will be suitable: A simple holder, which the

* "Dental Metallurgy."

operator himself can easily construct, may be made of a circular or semi-elliptical piece of heavy sheet iron, the margin of which is serrated and turned at right angles, forming a cup. To the under side and center of this an iron rod, ten or twelve inches long, may be permanently riveted, or it may be made to revolve on the handle, so that the heat may be thrown directly upon any particular part of the piece to be soldered without disturbing the latter.

A small *hand furnace* (Fig. 29) is sometimes used, and will be found a very convenient and useful apparatus, not only for

FIG. 29.



soldering, but for preparatory heating. It consists of a funnel-shaped receptacle made of sheet iron, with a light grate or perforated plate of the same material adjusted near the bottom, and an opening on one side, underneath the grate, for the admission of air. The upper part of the holder is surmounted by a cone-shaped top, which may be readily removed by a handle attached to it, while to the bottom of the furnace is attached an iron rod, five or six inches long and terminating in a wooden handle. The piece to be soldered is to be placed inside on a bed of charcoal, the top adjusted to its place, and the fuel ignited; when the case

is sufficiently heated, the top may be lifted off, and the piece remaining in the furnace soldered with the blowpipe in the usual manner, the furnace thus serving the purpose of a holder.

The Melotte Clamp or Support.—Two forms of a very simple and convenient clamp or support, devised by Dr. George W. Melotte, of Ithaca, N. Y., are shown in Figs. 30 and 31, and are especially designed for crown- and bridge-work.

It is the design of this invention to provide means for holding

FIG. 30.

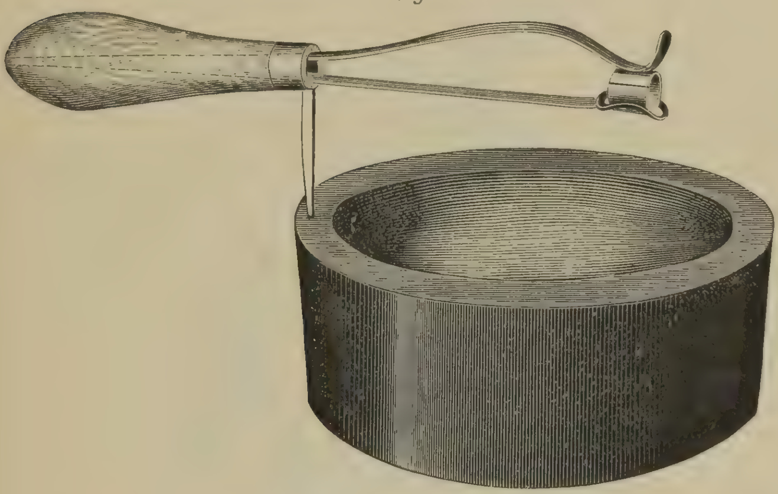
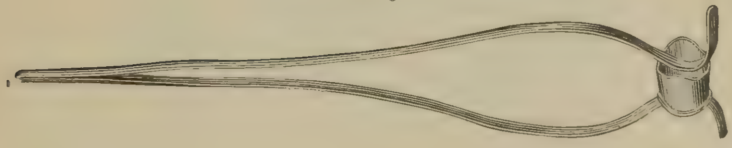


FIG. 31.



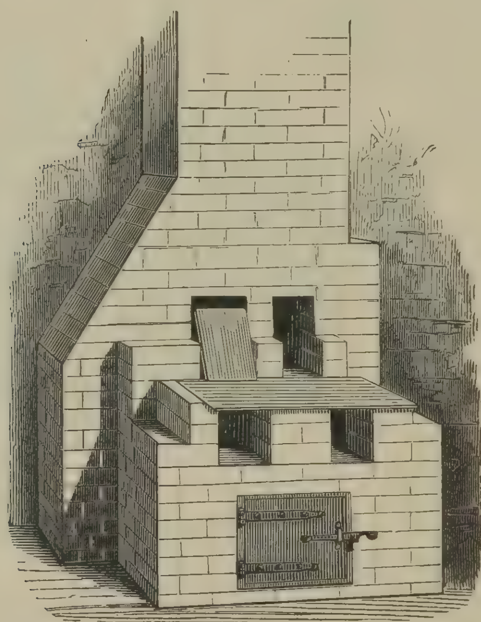
gold crown collars and their caps so that without change of size or shape their closed joints can be neatly soldered. Fig. 30 exhibits a collar, and Fig. 31 a collar and cap thus held. A slight pressure suffices, and this is effected by pushing the jaw shank into the handle, which by its spur is then fixed in a piece of charcoal or on the bench; the jaws turn in the handle to bring the joint into position, when the left hand is set free to manipulate the solder while the blowpipe is directed by the right hand

as usual. The cuts are two-thirds size, and the set consists of Nos. 1 and 2, the latter shown without the handle, which will grip either shank.

FURNACES.

It would be inconsistent with the design of the present work to introduce a description of any form of furnace other than those of practical use to the dentist. Many of those used in the arts, or for chemical and pharmaceutical purposes, embrace

FIG. 32.



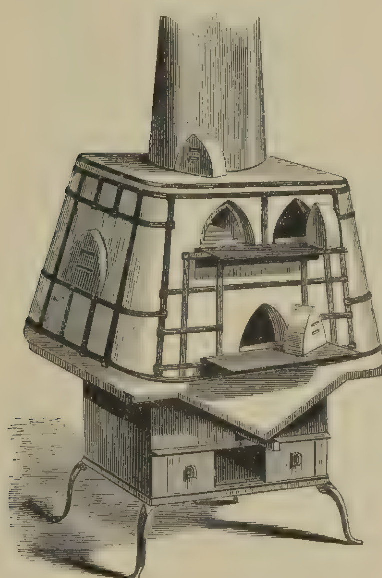
almost endless varieties, and have no special adaptation to the uses required of them in the dental laboratory.

Draft or Wind Furnace.—A very convenient, portable, and economical furnace may be made of sheet iron, of any desired shape or dimensions, though usually of small size and cylindrical in form. A light grate, or heavy piece of sheet iron, perforated with holes, to admit of the passage of air, should be adjusted near the bottom, while above and below the grate are

two openings, the lower one communicating with the ash pit, and the upper one for the introduction of fuel and substances to be heated. By surmounting this simple apparatus with a pipe, or connecting it with the flue of a chimney, it will be found efficient in many of the minor operations of the shop, as melting metals, heating pieces preparatory to soldering, annealing, etc.

A more durable and serviceable draft furnace, however, may be built of masonry, a convenient form of which is repre-

FIG. 33.



sented in Fig. 32. The construction of this stationary fixture is so plainly exhibited in the cut that any extended description of it is deemed unnecessary. The upper holes represent the entrance to the fire chambers, which are distinct from each other; the lower ones communicate with the ash pit, which is common to both chambers. Two fire apartments are here shown, one for melting and refining the more precious metals, heating up for soldering, etc., the other being used exclusively for fusing the baser metals, as zinc, antimony, lead, etc. These

furnaces are sometimes constructed with a single fire chamber, but the one exhibited is in every way preferable.

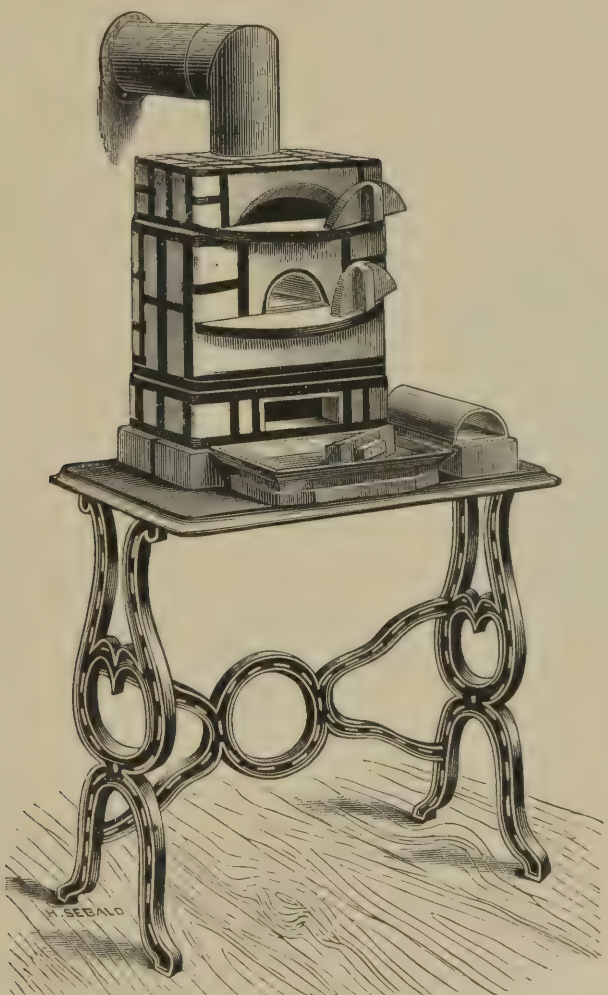
Baking Furnace.—The chief purposes to which these furnaces are applied are the manufacture of porcelain teeth, single and in sectional blocks, the preparation of silicious compounds, and the construction of what is known as "continuous-gum work." One of the most approved forms of this furnace is exhibited in Fig. 33.

The body of the furnace rests upon a cast-iron framework or basement, which serves the purpose of an ash pit. The grate immediately over this inclines from each side of the furnace toward the bottom and the center of the ash pit, to afford more ample room for fuel directly underneath the lower muffle. The upper portion or body of the furnace is made of fire clay, and contains three muffles arranged horizontally; the upper two, termed "annealing muffles," are designed more especially for drying substances, partial heating preparatory to final baking, and to receive substances from the lower muffle to be gradually cooled. The lower or main muffle is for general baking purposes requiring the employment of extreme degrees of heat. Each muffle is provided with fire-clay slabs or slides, on which substances to be heated are placed and introduced into the muffles; and also plugs of the same material to close the openings to the former. Openings are made on each side of the furnace, intermediate between the muffles, for the introduction of fuel, and to afford ready access to the latter with tongs or other implements. These entrances are also provided with plugs, which are applied during the process of heating. This furnace should be connected with a flue having a strong and unobstructed draft.

The Tees Furnace.—A furnace of somewhat similar construction, devised by Dr. Ambler Tees, is shown in Fig. 34. Dr. Tees, in a communication to the author, says concerning this appliance, which he designates as the "Lilliput" furnace: "Continuous-gum work has heretofore been looked upon as formidable, on account of the necessity of using large furnaces to obtain the requisite degree of heat; but since the introduction of the Lilliput furnace, in 1880, and the systematic way of managing it, it has become a pleasure instead of a terror."

This little furnace is made of fire-clay; it is but 15½ inches high, 12 inches wide, and 8 inches deep, with walls 1 inch

FIG. 34.

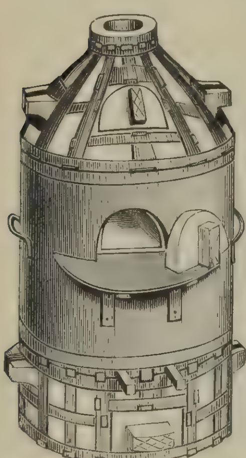


thick; being divided into three sections, it can be handled and managed by a child. Scarcely more than half a peck of coke is necessary for each heat. In the fall, winter, and spring, when

the draft is at its best, a coat of body can be fused in about thirty-five minutes after the fire is lighted, and in the summer within fifty minutes. By having the coke properly screened, and the kindling wood dry, and a convenient receptacle for them, the labor of starting the fire is scarcely more than lighting the gas. It is for sale, with all the necessary appurtenances, by dental dealers.

A modification of the last-named furnaces, more recently and especially designed and introduced for continuous-gum work, is exhibited in Fig. 35. The fire pit below the muffle is of more than usual capacity, insuring, it is claimed, perfect results at each baking. The part which is subjected to the greatest heat is free from angles and incased with sheet iron, rendering it less liable to crack from long use. The fire or ashes may be withdrawn by removing the two projecting grate bars. It is 24 inches high and 12¼ inches in diameter.

Fig. 35.



As the purposes, heretofore stated, for which these several furnaces are designed require a steady, intense and persistent heat, the fuels commonly used, as fulfilling most perfectly these indications, are coke, or a mixture of charcoal and coke, and anthracite, preference being given, by many, to the latter.

It will be observed that, in connection with the several kinds of furnaces heretofore mentioned, heat is generated by the use of solid fuels. Within the past few years, baking or muffle furnaces have been constructed with reference to their special adaptability to the use of gas in combination with the air blast. While these later devices commend themselves on the score of their greater convenience and economy of time in firing, and their freedom from the dirt and smoke attending the use of solid fuels, their successful application to the special uses for which they are mainly designed, has been attended with difficulties which have heretofore been adverse to their general adoption by

the profession, and which it has been the aim of inventors to overcome. This has been measurably, if not entirely, accomplished, and the successes so far attained give fair promise of a complete revolution, at no distant day, in the modes of applying heat in all operations concerned in the fabrication of the various forms of dental porcelain. Perhaps the chief obstacle to the successful use of gas in connection with the air blast in the processes relating to the manufacture of porcelain teeth, gum enamels, continuous-gum work, etc., is in the increased liability to so-called "gasing," or the formation of bubbles, due to absorption and elimination of gas that finds its way into the muffle during the process of baking. The manner in which this accident occurs is thus accounted for in a communication to the author from Dr. C. H. Land, of Detroit, Michigan. Alluding to the kind of furnaces under consideration, the writer says:—

"To be able to fuse the body and enamel of which artificial teeth are composed in an easy and convenient manner is a thing the profession have studiously sought after, realizing that, when properly accomplished, the means to elevate prosthetic dentistry from an ordinary mechanical enterprise to one of true art, would be at hand. The mere construction of a furnace after the usual modes has been simple enough, and the question of securing the necessary degree of heat was long ago accomplished. However, the ideal furnace demanded much more. It must possess not only the capacity of a coal or coke fire, but also accomplish the work in less time, and require but the minimum amount of exertion to operate it. Of the many attempts to produce such, nearly all have failed, owing to technicalities that were not well understood.

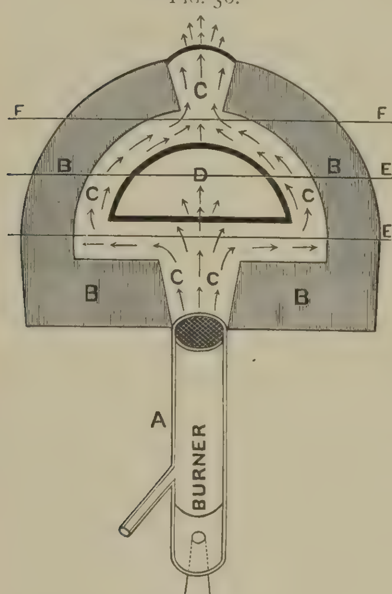
"After many experiments, and their accompanying failures, it has been demonstrated that to heat an eight-inch muffle, three and one-half by two and one-half inches in diameter, to over 2800° F., represents about a one-man power equivalent to the exertion of running the ordinary foot lathe or the No. 9 bellows, as manufactured by the Buffalo Dental Manufacturing Company, which gives a working pressure of one and one-half pounds to the square inch, and corresponds exactly to the required amount of air pressure and volume necessary to heat an eight-inch

muffle to 2800° F. Therefore, to make a furnace larger would require too much power, and one smaller would not do for large pieces of work. In the production of a suitable furnace, the whole working apparatus must be as nearly air-tight as possible, the supply of gas and air must be easily controlled and well balanced, with the least amount of friction in the passage through the pipes. These, with many minor details, form the basis of a practical gas furnace.

GASING THE BODY AND ENAMEL.

"The most serious trouble with all gas furnaces has been the extreme liability of injuring the body and enamel by what has been commonly called 'gasing.' The accompanying illustration, Fig. 36, will make the philosophy of combustion more clear, and give the reasons why teeth are injured. A represents the burner; B B B, fire-brick lining; C C C, combustion chamber; D, interior of muffle. The arrows indicate the direction of the blast. The space in the combustion chamber between the lines E E is where carbon monoxid is formed, a gas containing one equivalent less of oxygen than carbon dioxid, simply an imperfect state of combustion. It is this gas that injures the body and enamel. By reference to the illustration, it will be seen that the little arrows are made to appear passing through the pores of the muffle, and as the direction of the blast from the burner A is directly against the bottom of the muffle, with a pressure of one pound to the square inch, a portion of the carbon monoxid is extremely liable to be forced through its pores, and will

Fig. 36.



be taken up with the body during the first and second biscuiting, here to remain until the enameling process, and as this takes a much higher degree of heat, it causes the gas to be eliminated, as shown in the numerous small bubbles on the surface. The space between the lines E E, and within the combustion chamber C C C, should be known as the first stage of combustion, where a certain portion of carbon monoxid is always present, and the space above the line F, within the chamber C, should be known as the second stage, which is perfect combustion. In the first stage of combustion one equivalent of oxygen from the atmosphere unites with the hydrocarbon to form carbon monoxid; in the second stage, two, or perhaps three, unite to form carbon dioxid, or carbonic acid. Perfect combustion is always at the extreme point of the blowpipe, as shown in the illustration.

"The attempt, therefore, should be to place the muffle as nearly as possible in the center of perfect combustion. As carbon monoxid is not consumed short of a temperature of over 2200° F., the teeth should be kept in front of the muffle until it approaches a white heat. Starting from a cold muffle this will take about twelve minutes, and they should be gradually carried to the extreme end. At a high temperature, there is very little danger of gasing, unless a greater quantity of gas is supplied than the furnace is capable of burning. Having constructed a furnace, and being familiar with many other details that provided a means to overcome all the apparent difficulties, the success of properly baking teeth seemed to be assured, until the muffle began to crack, which usually started in the second or third enameling heat. This let in such a quantity of monoxid of carbon as to ruin the teeth. Here was a difficulty that was overcome by forcing a quantity of superheated air into the muffle, and backing all foul gases out. This proved to be a cure for gasing, but added an excess of oxygen, and it was found that this had a tendency to bleach the gum enamel to a lighter shade. The next step was to inject a pure atmosphere of nitrogen into the muffle, it being a neutral gas, not uniting radically with anything. This was eminently successful, and thoroughly demonstrated the fact that porcelain baked in an atmosphere of nitrogen was absolutely perfect, both in color and texture. It therefore

gives me pleasure to be able to announce to the profession that the baking of all kinds of porcelain with any of the hydrocarbons has been brought within the range of every dental practitioner, so that, with a little experience and knowledge of the above facts, artificial teeth can be baked, with unerring precision, in a very comfortable, cheap and easy manner. By a simple attachment, each furnace produces its own nitrogen as fast as needed, and with recent improvements in the construction of muffles, and the aid of a small motor, the author has been able to maintain a constant and uniform temperature above 2800° F., by which a slab of sectional gum teeth was completed every seven minutes, at the will of the operator.

OLEFIANT GAS AND GASOLENE.

" Olefiant gas, with which nearly all our cities and towns are supplied, is a compound of hydrogen and carbon. Its symbols are C_2H_4, differing from gasolene only in its specific gravity, the composition of the latter being also C_2H_4. The former will rise to the top of a building, while the latter will fall. The former is more penetrating, therefore more liable to gas the teeth, and hence requires more care in handling. The quality varies in different localities, and sometimes, owing to the presence of ammonia, it may injure the teeth, or it may be too thin. When properly purified, it should be a rich hydrocarbon. The uncertainty of its qualities is frequently the cause of failure. To be successful with gas furnaces, it is absolutely necessary to have a pure and rich hydrocarbon. When the gas pressure is weak or the quality is poor, a gasolene generator may be attached to the pipe and the current allowed to pass through. This takes up a large percentage of the gasolene and provides a very rich quality of gas. The eighty-seven per cent. is the best; seventy-four per cent. is too heavy to use without requiring heat to vaporize it. By applying to the Combination Gas Machine Company a supply can be had. When pure gasolene is used, it is necessary to have a generator so arranged that a portion of the air from the bellows will pass through it. This carries the vapor into the furnace, where it becomes mixed with the proper quantity of air, and will produce as good, if not better, results

than any other hydrocarbon. All kinds of crucible and muffle work can be done equally well, also soldering and brazing with the blowpipe. One gallon of gasolene costs fifteen to twenty cents ; this will bake one set of teeth. Therefore it will be seen that dentists living in localities where there is no gas will not be deprived of practically the same advantages as their city brethren."

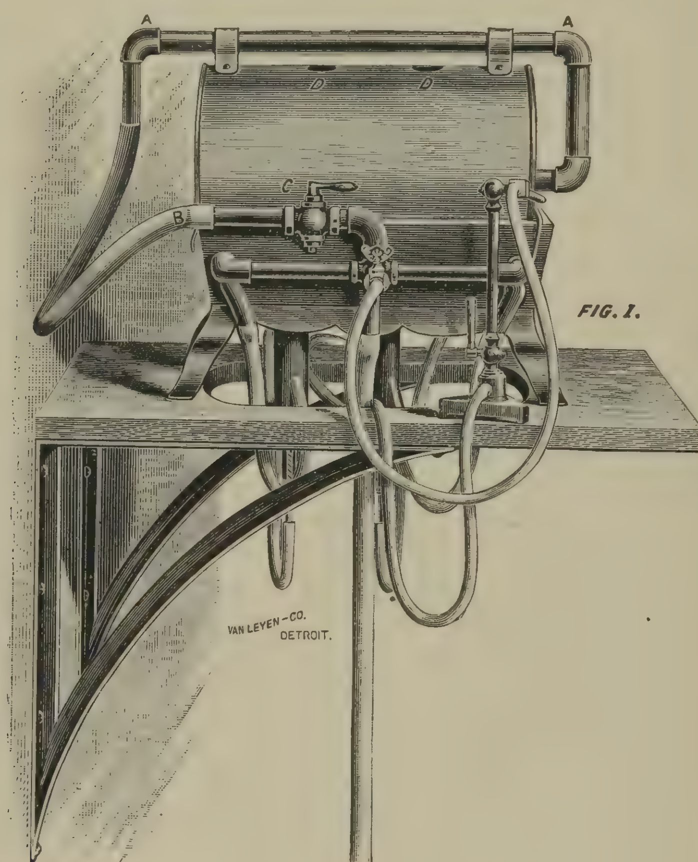
The Land Furnace.—The following is a description of a furnace, invented by Dr. Land, designed especially to overcome the trouble spoken of above, as well as to provide other advantages :—

Size No. 1 is especially adapted for all kinds of muffle work, crucible work, blowpipe work, forging and brazing, assaying, and small castings of iron, brass and steel. A muffle 8 inches long, 3½ inches wide, 2½ inches high, inside measurement, can be heated to over 3240° F. in twenty-five minutes, sufficient to melt wrought iron. Fig. 37 represents the furnace closed and ready for muffle work. A A is an iron pipe, capable of both a sliding and a swinging motion (see L, Fig. 38), to which the door or plug is securely attached. There is a small hole in the door, covered with a piece of mica, through which all operations can be seen. Observe that the iron pipe is connected with rubber tubing, B, and with pipe having an air cock, C, which regulates the quantity of air passing into the mouth of the muffle. It will also be noticed that the pipe passes over the two holes, D D ; thus by the escaping flame the pipe is heated to redness and provides a superheated air before reaching the muffle ; this column of air forced into the muffle keeps up a counter pressure within, so much greater than the pressure produced by the blast within the fire chamber that all foul gases are prevented from entering the muffle even though it is cracked ; thus the most delicate porcelain can be baked without the least danger of so-called gasing. Also, it will be seen that by connecting the rubber pipe with retorts of gasometers any desired vapor or gas could be forced into the muffle, making the furnace invaluable for scientific experiments.

Fig. 38 illustrates the furnace thrown open, being swung on hinges at the back, exposing the muffle, E. The groove, P P, is packed with asbestos fiber, so that when the sections are brought

together the furnace will be perfectly air and gas tight. The hooks, F F, are to hold the upper section secure to the lower. The gas and air connections are so arranged that the ordinary blowpipe can be attached, as shown at G. When the muffle, E,

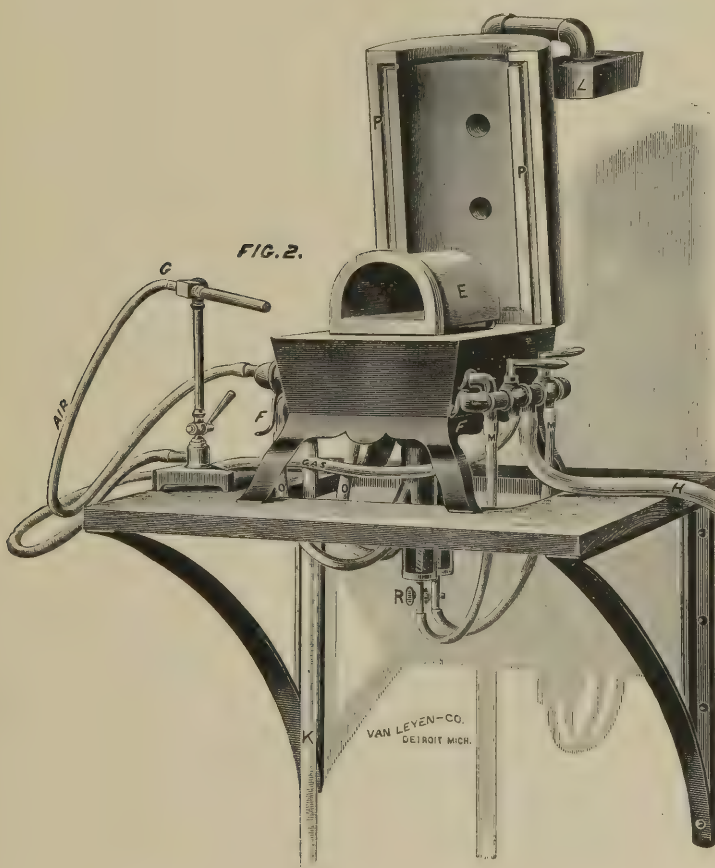
Fig. 37.



is removed, it exposes two burners and a fire-brick surface made to fit the various appliances for crucible, ladle, and blowpipe work. One or both burners can be operated in conjunction with the blowpipe, G. The air cock, R, is to provide a means for shutting off the air supply from either burner when required.

H is the gas supply; K, air pipe connecting with the bellows. Size of muffle, inside measurement, 8 inches long, 3½ inches wide, 2½ inches high. With gasolene gas porcelain teeth can be enameled in from 10 to 15 minutes; with ordinary city gas

FIG. 38.



in from 15 to 25 minutes, according to quality. In 30 minutes a heat sufficient to destroy the muffle can be produced, which indicates a temperature of over 3240° F., much higher than is ever needed for any kind of work, except the fusing of platinum.

5

Three-eighths inch gas pipe will supply sufficient gas and can be worked with ordinary foot bellows.

The Rollins Furnace.—A gas muffle furnace, with hot-air blast attachment, invented by Dr. William Herbert Rollins, of Boston, Mass., is exhibited in Figs. 39 and 40. This furnace, designed especially for firing dental enamels and porcelains and for continuous-gum work, has been used successfully by the inventor for several years, and ranks among the best of its kind for the purposes indicated. The following abstract, taken from a paper read before the Society for the Advancement of Oral Science and subsequently published, with illustrations, in the "Items of Interest," is descriptive of the appliance under consideration :—

FIG. 39.

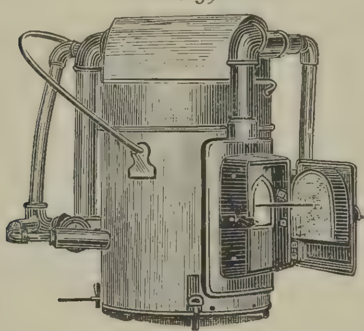
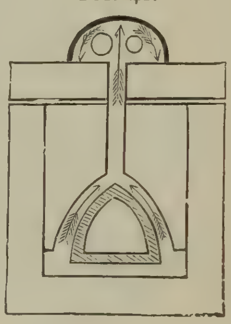


FIG. 40.



"The furnace shown in Figs. 39 and 40 will give a heat from a dull red to a light so bright that an object in the muffle is invisible. Looking at the figures will enable any dentist, by means of the following brief description, to make a similar one: The furnace consists of a cylinder of sheet iron ten inches in diameter and eleven inches high. It has a handle and an iron door. The cover is a similar cylinder, two inches deep. Both are lined with porous fire-clay, two inches thick. The furnace walls have four holes in them. Three of these holes give passage to three tuyeres, the fourth is for a No. 3 muffle, the mouth of which is closed by an iron door lined with asbestos. The door is perforated by a platinum tube, through which passes the platinum trial rod, with a small spoon end for the test piece. This rod

can be withdrawn from time to time, to look at the test piece. At the front of the furnace are two iron tubes, one for gas, the other for air. These pass under the fire-clay arch, where they are brought to a yellow heat by the waste gases as they escape through the slit in the top of the furnace. (See Fig. 40.) Each of these tubes divide into three branches at the back of the furnace, where the gas tubes enter the air tubes. In this way three double tuyeres are made, their mouths corresponding to the holes in the furnace. This arrangement is necessary, for if the heated air and gas are allowed to mix before reaching the mouths of the tuyeres these would be destroyed by the intense heat. Fig. 40 is a perpendicular section of the furnace. The course of the heated gases is indicated by the arrows."

As matter having intimate relation to the baking of dental porcelain by the means described and illustrated in these pages, the following observations of Dr. Rollins, in discussing the causes of "gasing" in firing mineral teeth, in addition to those offered by Dr. Land on the same subject, will not be without interest to those having the management of furnaces used for ceramic processes in the dental laboratory. He says:—

"In my first experiments for making enamels for filling conspicuous cavities in teeth, difficulty was sometimes found in making the enamel base of a pure translucent white. As the result of somewhat elaborate tests, it was found that the gray or green tint was due to the reduction of some of the lead oxid. A similar difficulty was encountered when the enamel base was fritted with the metallic oxids necessary to give it the shade of the teeth. Here the oxids themselves were reduced.

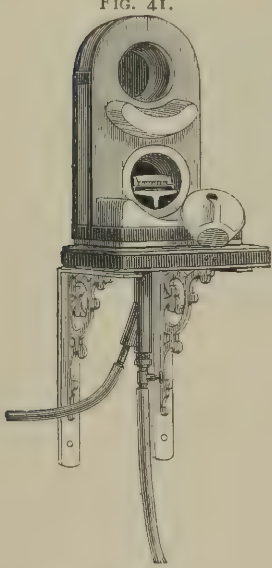
"It, therefore, seemed probable that the so-called gasing in mineral teeth came from a similar cause.

"Many experiments and analyses were made to test the matter, and though it is not worth while to give these in detail, one experiment, which is easily tried, will be mentioned: After having made a furnace like the one described, light the gas and open the air valve. When the heat is high enough, put an unbaked tooth into the muffle. When taken out the color will be pure. Now diminish the oxygen by partly closing the air valve. Put in another unbaked tooth. When this is removed it will be found

gased. The same result will follow with the air valve in the same position as in the first experiment, if the supply of gas is increased. In experiments with dental enamels and porcelain, it is advisable to have a slight excess of air in the furnace. Where the color used, as, for example, platinum, yields the proper tint in the metallic state, this precaution is unnecessary, as in these cases the color has no oxygen to give up."

The Ferrier's Furnace, Fig. 41, is a compact and convenient heater designed especially for continuous-gum work; it is operated with gas and the air blast of an ordinary foot blower. By this means a heat is generated sufficient to fuse gum body and enamel in a much shorter time than when solid fuel is used in connection with coke or anthracite furnaces. In commendation of this furnace, the inventor says: "This furnace, combining cleanliness, utility, simplicity, certainty, economy and durability, which is the outcome of years of experiments, has been brought to the minimum of difficulty with the maximum for working, for, although only six inches cube, sufficient heat can be produced in from five to ten minutes to fuse the gum body or enamel for continuous-gum facings (or work) for mounting on vulcanite, celluloid, or gold."

FIG. 41.



Gas Crucible Furnace Without Blast.—Fig. 42 represents a small crucible furnace that will be found very convenient for melting and refining the precious and more infusible metals employed by the dentist. It takes crucibles up to 2½ by 2¼ inches outside, and with a three-foot chimney will melt copper, gold, silver, etc., in about ten minutes, or cast iron in thirty minutes from the time the gas is lighted.

The construction of the burner used with this furnace is illustrated by the sectional diagram, Fig. 43, and is thus described: "The gas enters a chamber at the bottom of the burner, through

a device similar to a Bunsen burner, mixing with air as it enters, and is burned at the upper ends of a series of concentric tubes, furnishing air spaces alternately with those supplying the mixture of gas and air. The whole burner is constructed of iron, and will be found better able to withstand an intense heat, more durable and quicker in its operation, than the old pattern with gun-metal tubes. In case metal should be spilled into the burner, it can be easily taken apart for its removal.

Fig. 42.

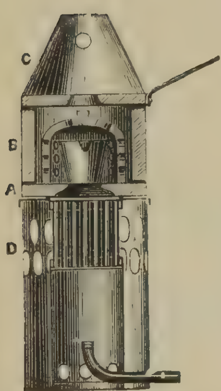
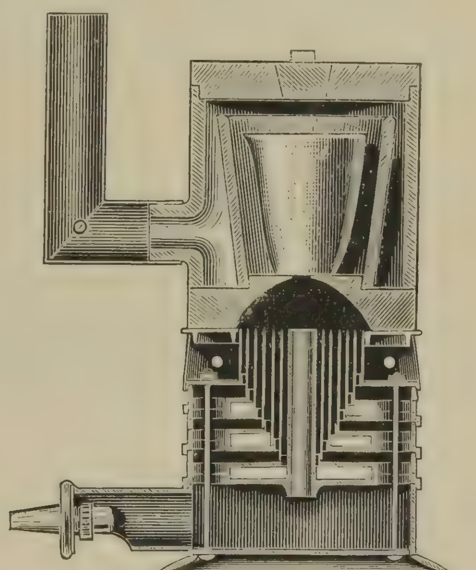


Fig. 43.



"Each part of the burner is lettered, and in case of accident it can be supplied at a small expense by specifying the letter on the piece desired.

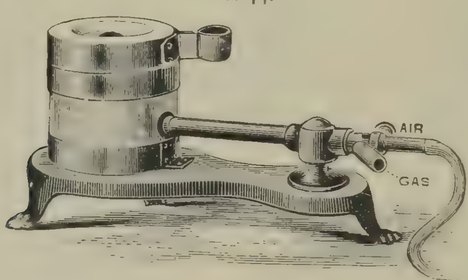
"The burner in its present shape is believed to be the most efficient and economical yet devised for furnace purposes."

The following instructions in the use of this furnace should be observed:—

"A chimney or stove pipe, eight or ten feet high, may be used as a fixture, and the draught partially stopped with a

damper or slide when lower temperatures are required, the gas being turned down in proportion; the guide for the proper adjustment being that UNDER ALL CIRCUMSTANCES THE FLAME MUST JUST COVER THE CRUCIBLE OR MUFFLE, but not extend into the chimney so as to make it red hot. When the flame covers the crucible or muffle the gas is doing its extreme duty under the most favorable circumstances, without waste. Particles of flux should not be allowed to fall on the fire-clay casing, where the parts touch each other; and the power of the furnace should not be urged too far by the use of very long chimneys, as there is danger of the fusion of the fire-clay parts together, so that they cannot be separated. Fire-clay fittings, as a rule, cannot be safely used for temperatures much exceeding the fusing point

FIG. 44.



of cast iron. *Plumbago fittings and crucibles must be heated slowly the first time they are used.* After the first time they may be subjected instantly to the full power of the furnace without injury."

Gas Crucible Furnaces with Blast.—A small, compact, and convenient crucible furnace is shown in Fig. 44. Of this simple but powerful heating apparatus, which will be found especially adapted to the necessities of the dental laboratory, the manufacturers * observe:—

"Owing to the discovery, by Mr. Fletcher, of a singularly perfect non-conducting furnace casing, we are enabled to produce the first really simple gas furnace ever constructed. This

* Buffalo Dental Manufacturing Company.

material is only about one-sixth the weight of fire-clay, and has not one-tenth its conducting power for heat.

"The furnace consists of a simple pot—for holding the crucible—with a lid and a blowpipe, all mounted on a suitable cast-iron base. As compared with the ordinary gas furnace it appears almost a toy, owing to its great simplicity.

"The casing holds the heat so perfectly that the most refractory substances can be fused with ease, using a common foot blower. Half a pound of cast iron requires from 7 to 12 minutes for perfect fusion, the time depending on the gas supply and pressure of air from the blower.

"The power which can be obtained is far beyond what is required for most purposes, and is limited only by the fusibility of the crucible and casing.

"The crucible will hold about ten ounces of gold.

"An ordinary gas supply pipe, $\frac{5}{16}$ or $\frac{3}{8}$, will work it efficiently. It requires a much smaller supply of gas than any other furnace known. About ten cubic feet per hour is sufficient for most purposes.

"Crucibles must not exceed $2\frac{1}{4}$ by 2 inches. Any common blowpipe bellows will work the furnace satisfactorily except for very high temperatures (fusion of steel, etc.), for which a heavy pressure of air is necessary.

"In adjusting this furnace for use, put the gauze nozzle of the burner closely against the hole in the side of the casing, turn on the gas, and light it in the furnace. Work the bellows and then put the cover on the furnace. The air supply should be such that a flame about two inches long will play out of the hole in the cover, and it may be adjusted by turning the thumb-screw on the side of burner. The amount of air and gas used by this burner is very small. Care should be taken that the right proportion of each should be used. A *very light* but steady blast of air will give the best results.

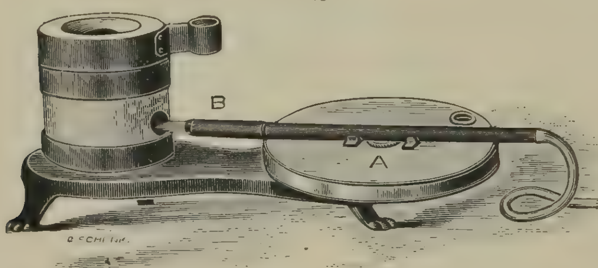
"A modified pattern of the foregoing furnace (Fig. 45) has been designed, retaining all the peculiar advantages of the one just described, but burning refined petroleum instead of gas as fuel, and is claimed to be equally as efficient as the gas furnace.

"The burner of this furnace is constructed upon the principle of an atomizer; and this, of course, dispenses with a wick. This method has proved the most efficient of any that has been experimented with.

"The recent improvements consist in a device for regulating the supply of oil, which is operated by the milled nut (marked A) shown on top of the reservoir in the cut, and the addition of an annular jet of air, which is regulated by turning the sleeve (marked B)."

An approved crucible furnace of recent introduction, known as Fletcher's injector gas furnace, is shown in Fig. 45. Of this heating apparatus Prof. Essig * says: "The construction of this apparatus is upon the principle of the injector furnace, and it is

FIG. 45.



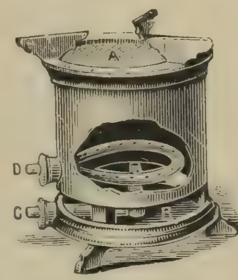
claimed that its power and speed of working are practically without limit, depending only upon the gas and air supply. With a half-inch gas pipe and the small foot blower this furnace will melt a crucible full of cast-iron scraps in ten minutes. The supply of gas required is exceedingly small. Allowing five cubic feet of gas for heating up, it consumes about four feet of gas for every pound of cast iron melted, and for laboratory purposes it is the cheapest and most convenient furnace in use. It is very simple in construction, and consists of two parts, an upper portion, which forms the cover, and a lower part, which holds the crucible while in operation."

A very useful and almost indispensable heating apparatus in

* "Dental Metallurgy," p. 77.

the dental laboratory, suitable for drying, boiling, melting metals requiring a moderate temperature, as zinc, tin, lead, etc., heating flasks preparatory to packing with rubber, and a variety of other purposes, is exhibited in Fig. 46.

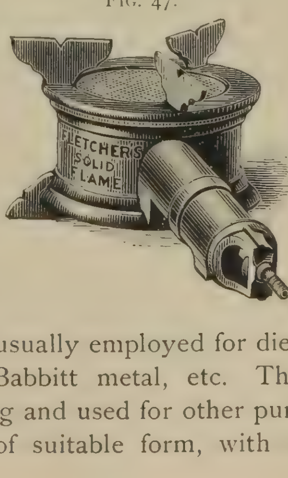
FIG. 46.



The burner, consisting, as will be seen, of a circular perforated gas tube, with a central air jet, gives a complete range of temperature, from a gentle current of warm air to a clear red heat, and is so perfectly under control that a common glass bottle may be placed on the tripod and heated to any required temperature without the slightest risk of fracture. For very low temperatures the ring must be lighted through the opening B. This gives a steady current of heated air through the gauze above. For boiling, melting, etc., the light must be applied on the surface of the gauze, thereby providing a large body of blue flame, which can be urged by the blast pipe C. This is one of the most generally useful burners, and stands hard, dirty work without injury. The gauze, if choked up with dirt, can be replaced in a few seconds.

An equally convenient heater for many purposes requiring a diminished temperature, as compared with the air-blast heater just described, is exhibited in Fig. 47. A gentle current of air passes through side openings in the end of the injecting tube, mingling with the gas supplied through a rubber tube attached to an ordinary gas burner.

FIG. 47.



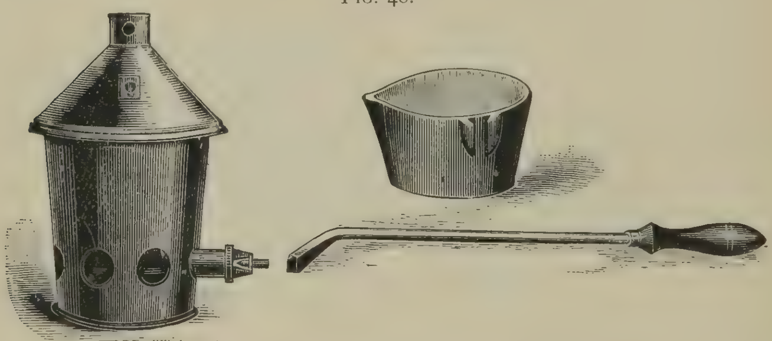
An admirably contrived ladle furnace, designed by Dr. Fletcher, is shown in Fig. 48. This simple contrivance, provided with a heating apparatus similar to the burner last described, is especially well adapted for melting any of the several metals usually employed for dies and counter-dies, as zinc, tin, lead, Babbitt metal, etc. The burner can be removed from the casing and used for other purposes if desired. A cast-iron ladle of suitable form, with a

detachable handle, which can be removed during the process of melting, is also illustrated.

CRUCIBLES.

Crucibles are small, conical-shaped vessels used by the dentist principally for the purpose of melting and refining metals used for plates, compounding metallic alloys, preparing and compounding the various ingredients employed in the manufacture of porcelain teeth, continuous-gum work, etc. They combine in a high degree the properties of infusibility, exemption from the attack of substances fused in them, the power of resisting sudden alternations of temperature and impermeability to fluids and gases. The Hessian crucibles, which are in most

FIG. 48.



common use among dentists, are composed of silica, alumina, and oxid of iron. Plumbago crucibles are also made from special patterns, and expressly designed for Fletcher's furnaces. For a more particular description of the various components entering into the structure of crucibles, as well as the manner of manufacturing them, the reader is referred to Piggot's "Dental Chemistry and Metallurgy," and other works treating more fully of the subject.

To avoid a possible loss of fused metals, which may occur in consequence of some imperfection in the crucible, a test trial should be made by placing in it a small quantity of borax and then subjecting it to a high heat. If imperfect, the borax, rendered semi-fluid by the heat, will pass through the substance of the crucible and glaze the surface on the outside.

CHAPTER III.

METALS EMPLOYED IN DENTAL LABORATORY OPERATIONS.

GOLD.

Au (Aurum).

Gold has been known from a period of great antiquity, having, according to the writings of Moses, been wrought into articles of jewelry more than three thousand years ago. As a base or support for artificial dentures, it has entirely superseded the use of the various animal substances formerly employed, and, by the mass of practitioners at the present time, it continues to be the most highly esteemed metal for the purpose mentioned, notwithstanding the more recent introduction of processes in which, as a base, this metal is wholly discarded.

Gold is found only in the metallic state, and occurs either crystallized in the cube and its allied forms, or in threads of various sizes, twisted and interlaced into a chain of minute octahedral crystals; also in spangles or roundish grains. These latter, when they occur of a certain magnitude, are called *pepitas*, some specimens of which have been obtained of great size. In 1810 a mass of alluvial gold weighing twenty-eight pounds was found in the gravel pits of the creeks of Rockhole, in North Carolina. A lump of gold ore weighing three cwt. was forwarded from Chili, South America, as a contribution to the World's Exhibition in London. New Granada, California, Russia, and Australia have each produced pepitas, or masses of gold weighing respectively twenty-seven and a half, twenty-eight, seventy, and one hundred and six pounds.

Geological Situations.—The crystalline primitive rocks, the compact transition rocks, the trachytic and trap rocks, and alluvial grounds are the formations in which gold occurs. Unlike many other metals, it is never in such large quantities as to constitute veins by itself, but is either disseminated through the

rocky masses, or spread out in thin plates or grains on their surface, or confined in their cavities in the shape of filaments or crystallized twigs. The minerals composing the veins are either quartz, calcspar, or sulphate of baryta. The ores associated with the gold in these veins are principally iron, copper, arsenical pyrites, galena, and blende. The most abundant sources of gold, however, are in alluvial grounds, where it is found distributed in the form of spangles in the sands of certain plains and rivers, especially at their re-entering angles, at the season of low water and after storms and temporary floods. Sufficient reasons have been advanced in support of the belief that gold found in alluvial situations belongs to the grounds traversed by these rivers, instead of being washed, as was formerly supposed, from the mountains in which their waters have their origin.

Geographical Distribution.—The *European* mines more particularly distinguished for their richness are in Hungary and Transylvania, especially the former. Gold also occurs, but more sparingly, in Ireland, Sweden, Siberia, Germany, Russia, Spain. In *Asia* and *Africa*, the mines which yield most abundantly are situated in the southern portion of these continents. From the latter, the ancients derived the greater portion of their gold. Several of the *South American* provinces yield this metal in considerable quantities. Washings are also common in several States of the Union, but California stands unrivaled, except by Australia, in the immense productiveness of its mines, and its resources in respect to this rare and valuable metal are reckoned inexhaustible.

Properties of Gold.—Pure gold is distinguished from all other metals by its brilliant orange-red or yellow color, being the only simple metal that possesses this complexion. It is susceptible to a high polish, but is inferior in brilliancy to steel, silver, or mercury. Its specific gravity varies somewhat, according as it is fused or hammered; the former having a density of 19.26, the latter ranging from 19.04 to 19.65. It is only excelled in density, therefore, by platinum, the specific gravity of which is 21.25.

Gold surpasses all other metals in malleability. The average thickness of ordinary gold leaf is $\frac{1}{282000}$ of an inch, but the

ultimate degree of attenuation to which pure gold is susceptible exceeds considerably this estimate. It is also distinguished for its ductility. A single grain of gold may be drawn into wire 500 feet in length, while an ounce may be made to extend 1300 miles. It is somewhat softer than silver, and possesses great tenacity, though inferior in this quality to iron, copper, platinum, or silver. A thread of gold $\frac{78}{1000}$ of an inch in diameter will sustain a weight of 150 pounds.

The fusing point of gold is 2016° F. It fuses with considerable expansion, and on cooling contracts more than any other metal.

On account of the want of affinity of gold for oxygen, it remains unaltered in the longest exposure; it is incapable of being oxidized in any heat that may be applied to it, and is only volatilized with great difficulty in the resistless heat of the oxy-hydrogen blowpipe. It is unaffected by the most concentrated of the simple acids, but is readily soluble in *aqua regia* or nitro-muriatic acid and nitro-fluoric acid.

It will thus be seen that gold possesses, in an eminent degree, those general properties which render it peculiarly fit for the purposes to which it is applied in the practice of dental prosthesis.

Influence of Alloying on the Properties of Gold.—The term *alloy* signifies a compound of any two or more metals, as brass, which is an alloy of copper and zinc.

Alloys, in respect of their uses, are practically new metals, and differ in many important respects, both in their chemical and physical characteristics, from the constituent metals of which they are composed. A more particular account of the influence of alloying upon the general properties of metals, and their management and behavior in the process of compounding, will be given under the head of alloys of the baser metals. As gold combines readily with most metals, some of the more prominent conditions which distinguish its alloys will be given.

The malleability of gold is, strictly speaking, always impaired by its union with other metals. This effect is eminently characteristic of certain contaminations, as those with arsenic, tin, antimony, bismuth, lead, etc.; while with certain other metals,

as silver, copper, and platinum, unless in excess, this property of gold is so little affected, as in no material degree to interfere with its being worked into any desired form for dental purposes. The *ductility* of gold is also usually diminished by its incorporation with foreign metals; sometimes in a remarkable degree. Gold is always rendered *harder*, and its *tenacity* is generally increased, by alloying, while its *density* varies with the particular metal or metals with which it is combined. Thus the alloy of gold with either zinc, tin, bismuth, antimony, or cobalt, has a density greater than that of the mean of its constituents, while the alloys of gold having a less specific gravity than the mean of their components are those with silver, iron, lead, copper, iridium, or nickel. Gold is ordinarily more *fusible* when alloyed, the alloy always melting *at a less heat than that required to fuse the most refractory constituent, and oftentimes less than the more fusible component.* The alloy of gold and platinum furnishes an example of the former; the platinum, which in its uncombined state is infusible in the highest heat of a blast furnace, forming a fusible compound with gold, the melting point of which is far below that of platinum. Gold solder, composed of gold, copper, and silver, affords a familiar illustration of the latter, the alloy melting at a less heat than that required to fuse its least refractory component, silver. Gold, which in its pure state has less affinity for oxygen than any other metal, is rendered more or less oxidizable when combined with other metals.

That gold alloys tend to be formed in definite proportions of their constituents would appear from the phenomenon observed in the native gold of the auriferous sands, which is an alloy with silver in the ratio of 1 atom of silver, united to 4, 5, 6, or 12 atoms of gold, but never with a fractional part of an atom. The same circumstance is noticed in connection with the amalgam of silver and mercury. But as alloys are generally soluble in each other, the definiteness of this atomic combination is obscured and disappears in most cases.

Properties of Particular Alloys of Gold.—The metals with which gold is liable to be contaminated in the dental laboratory are zinc, tin, lead, antimony, bismuth, iron or steel, mercury, and arsenic; as also excess of silver, copper, and platinum. As

several of these metals when alloyed with gold, even in very minute quantities, are highly destructive in their influence upon those properties which adapt this metal to the various wants of the mechanical operator, and as their separation is often attended with considerable difficulty, annoyance, and loss of time, it is practically important that care should be taken to prevent, as far as practicable, the admixture of any one or more of them with the gold scrap, filings, or sweepings that are to be reconverted into proper form for use. The accidental intrusion of these metals, however, is, to some extent, unavoidable, and as an acquaintance with the more prominent characteristics or sensible properties of the resulting alloys sometimes furnishes valuable indications in the selection of the proper reagents employed in their purification, a description of individual alloys is introduced.

Tin, antimony, bismuth, lead, and arsenic, are peculiarly prominent in their effects upon the malleability of gold; either of these metals in exceedingly minute quantities render gold intractable.

One part of *antimony* with nine parts of gold, form a pale, brittle alloy, and in the proportion of one part of the former to 1920 of gold, the resulting compound is too brittle to admit of successful lamination.

An alloy of *arsenic* with gold containing $\frac{1}{240}$ of the former is a gray, brittle metal, while in the proportion of $\frac{1}{900}$, the malleability of the gold is seriously impaired without suffering any change of color. So energetic is the influence of this metal on gold that the latter is rendered brittle when subjected even to the vapor of arsenic.

Tin, lead, and bismuth are somewhat analogous to arsenic in their influence upon the malleability of gold, either of them, in almost inappreciable quantities, rendering the latter metal unmanageable under the rollers. One part of lead or bismuth to 1920 of gold converts the latter into an unmalleable metal, while tin exceeds either in its remarkable tendency to render gold hard and brittle. Alloys of gold with tin are of a light color; those with lead are of a darker complexion.

Zinc with gold forms a brittle alloy, and when combined in equal proportions is exceeding hard, white, and brittle. Uniting

or incorporating itself less intimately with the gold than either lead or tin, however, it not infrequently happens that portions of the ingot will be brittle while others remain, in some degree, malleable; so that the bar, when rolled out in the form of plate, will be perforated or cracked at those points where the zinc predominates, while remaining portions of the plate retain a moderate degree of softness and pliability.

The working properties of gold are not sensibly affected by the incorporation of very small quantities of *iron*, as an alloy of these metals, in the proportion of one part of the latter to eleven of gold, remains malleable.

Platinum, in itself a highly refractory metal, is, as before stated, rendered fusible in combination with other metals. When combined with gold in small proportions, the latter is rendered harder and more elastic without having its malleability practically impaired. Platinum very readily affects the color of gold, the smallest quantities rendering the alloy pale and dull-colored.

Silver unites with gold in every proportion, and is the chief metal employed in the reduction of gold to the required forms for dental uses. It renders gold more fusible, and imparts to it increased hardness without materially affecting its malleability. The alloy is light-colored in proportion to the amount of silver introduced.

Copper, like silver, is usually combined with gold in the formation of plate, solders, etc., and hardens and renders gold tougher without practically impairing its malleability. It imparts to the alloy a deeper red color, and in the form of plate is capable of receiving a polish excelling in richness and briliancy any other metal.

The foregoing alloys of gold, it will be perceived, are such as result from the incorporation with gold of minute proportions of any one of the base metals mentioned, and possess certain physical characteristics that indicate, with tolerable certainty, the particular alloying component. Thus, for example, if the alloy is light-colored and very brittle, the presence of tin may be suspected; if brittle and dull-colored, lead is indicated; if grayish or dull-colored, but still malleable, tough and elastic,

platinum is probably present; if unequally malleable, or brittle in spots, the presence of zinc may be inferred.

Alloys of gold, however, embracing several or all of these metals in varying proportions, are sometimes accidentally formed, in which case the more distinctive features which characterize the binary compounds are lost or obscured.

CHAPTER IV.

REFINING GOLD.

Elements Employed.—The separation of foreign metals from gold by what is termed the "dry method," or *roasting*, is effected by the action on them of either oxygen, chlorin, or sulphur, converting them into oxids, chlorids, or sulphurets. Certain compound substances are used for this purpose which, when heated and decomposed, yield these elements in sufficient quantities for the purposes specified. The refining agents in common use are *nitrate of potassa* (nitre, or saltpetre), which yields oxygen; *chlorid of mercury* (corrosive sublimate), which yields chlorin; and *sulphuret of antimony* (crude antimony), which yields sulphur. Other compounds contain these elements, but those mentioned are generally preferred because they contain them abundantly, are readily decomposed by heat, and do not materially interfere with the process of separation by the introduction of troublesome components into the alloy.

Before considering specifically the different modes of refining alloys of gold, it will be convenient to classify the different forms of gold as they occur in working this metal in the laboratory.

1. Plate-scrap or clippings, and plate-filings. These, if proper care is taken to prevent the introduction of fragments of platinum, impure filings, or particles of base metals, only require, provided they were originally of suitable fineness, to be remelted and again converted into plate or other forms for use.

2. Mixed filings, and fragments containing solder, platinum, etc. These, when melted alone, produce an alloy more or less impoverished in proportion to the quantity and quality of the foreign metals introduced in finishing pieces constructed of gold, and should either be separately refined by roasting, or reduced to pure gold by the "humid method," to be described hereafter.

3. Sweepings. This form embraces many impurites, earthy and metallic, and should first be thoroughly washed, to remove

the earthy constituents, after which the remaining metals may either be mixed with class second, or separately refined. Another and perhaps better method, is to fuse together the sweepings and substances hereinafter mentioned, in the following proportions: Of sweepings, eight parts; chlorid of sodium, four parts; impure carbonate of potassa, four parts; impure supertartrate of potassa, one part; and nitrate potassa, half part. Mix them thoroughly together, and melt in a crucible. The crucible with its contents should remain in the fire for some time, in order to secure a complete separation of the metals from extraneous matter.

It is evident from the above classification that much time and labor may be saved by preserving these forms of gold separately as they accumulate in the laboratory. Separate lap-skins or receptacles, therefore, should be appropriated to the working of gold, one to receive scrap and unmixed plate-filings, which may be reconverted into plate without refining; another to collect the solder-filings, and such impure fragments as require purification.

Separation of Foreign Metals from Gold.—The most troublesome ingredients which find their way into gold alloys are what are commonly called *base* metals, as tin, lead, zinc, iron, antimony, bismuth, etc. In attempting to separate these metals from gold, it is not a matter of indifference what reagent is employed, inasmuch as distinct affinities exist, which may be advantageously consulted. If, for example, zinc or iron or both of these metals are present in small quantities, any compound which yields oxygen will, by virtue of the affinity of the latter for these metals, effect their separation by converting them into oxids; hence, when these metals are to be got rid of, nitrate of potassa is employed. But oxygen has a feeble affinity for tin, and when this metal is present, its separation is better effected by some compound which parts with chlorin in the act of decomposition; chlorid of mercury is therefore used for the purpose. When the alloy of gold contains a number of these metals at the same time, and is very coarse, sulphuret of antimony, which is a very powerful and efficient reagent, should be resorted to, unless the operator should prefer, and which is the

better way, to reduce the alloy to pure gold by the "humid method."

The Dry Method.—After all traces of iron or steel have been removed from the gold fragments and filings by passing a magnet repeatedly through them, the latter should be placed in a clean crucible, lined on the inside with borax, and covered either with a piece of fire-clay slab, or broken crucible. Sheet-iron has been recommended for the latter purpose, *but should never be used, as, when highly heated, scales form on the surface, and are liable to drop in upon the fused metals.* If the operation is likely to be protracted, an inverted crucible, with a hole in the bottom, may be securely luted to the top of the one containing the metals; the refining agents and fluxes being introduced through the opening in the upper crucible. These are then placed in the furnace, on a bed of charcoal, or what is better, a mixture of charcoal and coke, the latter being built up around the crucible, and over it when covered with a second crucible, care being taken that no fragments of fuel are permitted to fall in upon the fused metals. The process is as follows:—

First melt the alloy at a high temperature, to oxidize the base metals; the refining agents may then be added in small quantities from time to time, and the heat continued from half an hour to an hour, according to the coarseness of the alloy. The agents first employed are borax, and potassium nitrate (KNO_3). The latter assists the oxidation by parting with its oxygen, when the foreign metals will generally become entirely oxidized and dissolved in the slag.

The crucible should be removed from the fire, and the metals allowed to cool gradually. The crucible may now be broken and the button of gold at the bottom removed and separated from the slag that covers it with a hammer. The gold should then be put into a fresh crucible and remelted for pouring into ingot-moulds, which should be previously warmed and oiled (see page 97). This treatment, with nitrate of potassa and borax, will usually be sufficient, as most metals are oxidizable. If, however, after hammering, annealing, and rolling the ingot, it should still be found brittle, it must be remelted, and some other refining agent employed to remove the traces of the base metals. If it is known

what foreign metal is present, the particular reagent which will most readily attack it should be used. But if, as is often the case, the alloy is of uncertain composition, or contains several metals having distinct affinities, the process becomes to some extent experimental, making it necessary to use first one refining agent and then another, until, from the appearance and the manipulation of the gold, it is found to be free from alloy. The special regents employed are as follows:—

When tin or lead is present, add mercuric chlorid, $HgCl_2$ (corrosive sublimate), and zinc chlorid, $ZnCl_4$, or lead chlorid, $PbCl_2$, are formed and with the mercury volatilized by the heat.

When silver is present, add to the molten alloy from two to four times its weight of antimony sulphid, Sb_2S_3; this must be added carefully and a little at a time. The heat decomposes the sulphid. The sulphur unites with the silver and other base metals, forming sulphids, while the antimony unites with the gold, forming a leaden-colored alloy. When effervescence has ceased, remove the crucible from the fire and allow it to cool. The antimony and gold alloy will be found in the bottom of the crucible, and the sulphids on the surface.

To separate the antimony from the gold, remelt the alloy and throw upon the molten mass a current of air from a blowpipe. Antimony oxid, Sb_2O_3, is formed and volatilized; continue the process until fumes cease to be given off.

When iridium is present, Prof. Essig, in writing upon the subject, says: "The little, hard grains occasionally met with in gold, upon which the file makes no impression, consist of iridium, or a native alloy of osmium and iridium, and are nôt combined with the gold, but merely disseminated through it. The only dry method of separating it from gold consists in alloying the latter with three times its weight in silver, by which means the specific gravity of the metal is so much lowered that iridium, which is very infusible and of a specific gravity of 21.1, will subside to the bottom of the crucible, when the gold and silver alloy may be poured or ladled off. As some of the gold will remain with the residue, more silver must be melted with it, the operation being repeated several times until nearly all the gold is

removed." The gold and silver alloy may then be separated as directed above.

When platinum is present. If, after treating the alloy with the reagents enumerated, it should be found malleable, but stiff or elastic, and of a rather dull color, it is due to the presence of platinum; and any further attempts to reduce it by the "dry process" will prove unavailing. It must then be subjected to what will hereafter be described as the "humid or wet method."

The Humid Method.—When it is desired to reduce the alloy to pure gold, which is generally advisable whenever the gold to be refined consists of very coarse filings, fragments of plate containing large quantities of solder, linings with platinum pins attached, particles of base metals, etc., the "humid or wet method," as it is called, should be employed. The solvents in common use for this purpose are nitric, sulphuric, and nitro-muriatic or hydrochloric acid; but as the desired results can be more conveniently and directly obtained by the use of the latter, or hydrochloric acid, this most available method alone will be given. The following practical remarks on the subject are from an article on the "Management of Gold,"* by Professor George Watt:—

"When the alloy is composed of metals differing but little in their affinities for oxygen, chlorin, etc., we resort to one of the 'wet methods.' And, in connection, we will only describe the one which we consider the most convenient and effectual for the practical dentist. It is effectual in all cases, as it always gives us pure gold.

"Let us, then, suppose that our gold alloy has become contaminated with platinum to such an extent that the color and elasticity of the plate are objectionable. The alloy should be dissolved in nitro-muriatic or hydrochloric acid, called *aqua regia*. The best proportions for aqua regia are three parts of hydrochloric acid to one of nitric. If the acids are at all good, four ounces of the aqua regia will be an abundance for an ounce of the alloy. The advantage of using the acids in the proportion

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* *Dental Register of the West*, vol. xii, p. 251.

of three to one, instead of two to one, as directed in most of the text-books, is, that when the solution is completed there is but little, if any, excess of nitric acid. If the acids be 'chemically pure,' four parts of the hydrochloric to one of the nitric produces still better results.

"By this process the metals are all converted into chlorids; and, as the chlorid of silver is insoluble, and has a greater specific gravity than the liquid, it is found as a grayish-white powder at the bottom of the vessel. The chlorids of the other metals, being soluble, remain in solution. By washing and pouring off, allowing the chlorid of silver time to settle to the bottom, the solution may be entirely separated from it.

"The object is now to precipitate the gold while the others remain in solution. This precipitation may be effected by any one of several different agents, but we will mention only the protosulphate of iron.

"This salt is the common green copperas of the shops, and, as it is always cheap and readily obtained, we need look no further. It should be dissolved in clean rain-water, and the solution should be filtered, and allowed to settle until perfectly clear. Then it is to be added gradually to the gold solution as long as a precipitate is formed, and even longer, as an excess will the better insure the precipitation of all the gold. The gold thus precipitated is a brown powder, having none of the appearances of gold in its ordinary state. The solution should now be filtered, or the gold should be allowed to settle to the bottom, where it may be washed after pouring off the solution. It is better to filter than decant in this case, as, frequently, particles of the gold float on the surface, and would be lost in the washings by the latter process.

"Minute traces of iron may adhere to the gold thus precipitated. These can be removed by digesting the gold in dilute sulphuric acid; and, when the process is properly conducted thus far, the result is *pure gold*, which may be melted, under carbonate of potash, in a crucible lined with borax, and reduced to the required carat."

CHAPTER V.

ALLOYS OF GOLD FOR DENTAL PURPOSES.

Gold in its pure state is rarely employed by the dentist in laboratory processes, on account of its softness and flexibility; it is, therefore, usually alloyed with such metals as impart to it —without practically impairing either its malleability, pliancy or purity—the degree of hardness, strength and elasticity necessary to resist the wear and strain to which an artificial piece constructed from it is unavoidably exposed in the mouth.

Reducing Metals.—The metals with which gold is usually combined are copper and silver. It is sometimes reduced with silver alone, many regarding the introduction of copper into the alloy as objectionable, as plate derived from it is supposed to be more readily tarnished and to communicate to the mouth a disagreeable metallic taste. This is unquestionably true if, as is sometimes the case, the copper used is in excess; when, in addition to the effects mentioned, gold, so debased, may become a source of positive injury to the organs of the mouth, as well as to the general health. The small proportions of copper usually employed in forming gold plate, however, are not likely to produce in any objectionable degree the consequences complained of, unless the fluids of the mouth are greatly perverted. If gold coin is used in the formation of plate, it may be sufficient to add silver alone, inasmuch as copper is already present; though, usually, additional quantities of the latter metal are added.

Required Fineness of Gold Plate.—Alloys of gold to be permanently worn in the mouth should be of such purity as will most certainly, under all the contingencies of health and disease, resist any chemical changes that would tend to compromise either the comfort or health of the patient. Evils of no inconsiderable magnitude are sometimes inflicted, either through

ignorance, carelessness or cupidity, by a disregard of this important requirement. If the general health of the patient remained always uniformly unimpaired, with the secretions of the mouth in their normal state, gold degraded to eighteen or even sixteen carats fine, would undergo no material changes in the mouth. But it must be remembered that, in addition to the corrosive agents introduced into the mouth from without, a variety of diseases, local and constitutional, effect important changes in the otherwise bland and innoxious fluids contained therein, which, from being alkaline or neutral, become more or less acidulated. Indigestion, with acid eructations ; gastro-enteritis ; ague ; inflammatory and typhoid fevers ; brain affections ; eruptive diseases ; rheumatism ; gout, etc., are some of the local and constitutional disorders almost uniformly imparting to the mucous and salivary secretions an acid reaction. When this condition of the secretions exists in connection with the use of gold readily acted on chemically by reason of its impoverishment, some degree of irritation of the tissues of the oral cavity is likely to ensue. Gold plate intended to be introduced into the mouth should not, therefore, as a general thing, be of a less standard of fineness than from eighteen to twenty carats. It may exceed this degree of purity in some cases, but will rarely or never, unless alloyed with platinum, admit of being used of a higher carat than the present American coin, which is 21.6 carats fine.

Formulas for Gold Plate used as a Base for Artificial Dentures.—Any of the following formulas may be employed in the formation of gold plate to be used as a base or support for artificial dentures. The relative proportions of the alloying components may be varied to suit the peculiar views or necessities of the manipulator. The estimated carat of the appended formulas is based on the fineness of the American gold pieces coined in 1837 and thereafter.

GOLD PLATE EIGHTEEN CARATS FINE.

Formula No. 1.	*Formula No.* 2.
18 dwts. pure gold,	20 dwts. gold coin,
4 dwts. fine copper,	2 dwts. fine copper,
2 dwts. fine silver.	2 dwts. fine silver.

GOLD PLATE NINETEEN CARATS FINE.

Formula No. 3.	*Formula No.* 4.
19 dwts. pure gold,	20 dwts. gold coin,
3 dwts. copper,	25 grs. copper,
2 dwts. silver.	40 + grs. silver.

GOLD PLATE TWENTY CARATS FINE.

Formula No. 5.	*Formula No.* 6.
20 dwts. pure gold,	20 dwts. gold coin,
2 dwts. copper,	18 grs. copper,
2 dwts. silver.	20 + grs. silver.

GOLD PLATE TWENTY-ONE CARATS FINE.

Formula No. 7.	*Formula No.* 8.	*Formula No.* 9.
21 dwts. pure gold,	20 dwts. gold coin,	20 dwts. gold coin,
2 dwts. copper,	13 + grs. silver.	6 grs. copper,
1 dwt. silver.		$7\frac{5}{7}$ grs. platinum.

GOLD PLATE TWENTY-TWO CARATS FINE.

Formula No. 10.

22 dwts. pure gold,
1 dwt. fine copper,
18 grs. silver,
6 grs. platinum.

The union of platinum with gold, as in Formula No. 10, furnishes an alloy rich in gold, while it imparts to the plate derived from it a reasonable degree of stiffness and elasticity; preserves in a good degree the characteristic color of fine gold; and does not materially impair its susceptibility of receiving a high polish. The amount of gold coin given in Formula No. 9 may be reduced with platinum alone, adding to it from eight to twelve grains; in which case, although the carat of the alloy is lowered, its absolute purity remains unaffected, and plate formed from it will better resist any changes in the mouth than gold coin itself.

Formulas for Gold Plate used for Clasps, Wire, Stays or Linings, Metallic Pivots, etc.—Gold used in the formation of clasps, stays, etc., is improved for these purposes by the addition of sufficient platinum to render it firmer and more elastic than the alloys ordinarily employed in the formation of plate as a

base. The advantages of this elastic property, in its application to the purposes under consideration, are, that clasps formed from such alloys will adapt themselves more accurately to the teeth, as, when partially spread apart on being forced over the crowns, they will spring together again and accurately embrace the more contracted portions. In the form of stays or backings, additional strength being imparted, a less amount of substance will be required; the elasticity of these supports, also, will not only lessen the chances of accident to the teeth themselves in mastication and otherwise, but preserve their proper position when temporarily disturbed by any of the forces applied to them. The same advantages last mentioned are obtained from this property in the use of metallic pivots.

Formula No. 1.	*Formula No.* 2.
20 dwts. pure gold,	20 dwts. coin gold,
2 dwts. fine copper,	8 grs. fine copper,
1 dwt. fine silver,	10 grs. silver.
1 dwt. platinum.	20 grs. platinum.

The alloy derived from either of these formulas will be twenty carats fine.

Gold Solders.—Solders are a class of alloys by means of which the several pieces of the same or of different metals are united to each other. They should be more fusible than the metals to be united, and should consist of such components as possess a strong affinity for the substances to be joined. They should also be as fine as the metals to which they are applied will admit of without endangering the latter. Solders of different degrees of fineness, therefore, should always be provided, from which the one most suitable for any given case may be selected.

The use of solders of doubtful or unknown composition should be avoided, and hence they should be compounded either from pure gold or gold coin.

The following formula taken from Prof. Harris's work on "Dental Surgery," page 666, recipe No. 3, may be used in connection with eighteen- or twenty-carat gold plate, and is sixteen carats fine:—

6 dwts. pure gold,
2 dwts. rosette copper,
1 dwt. fine silver.

Recipes Nos. 1 and 2, page 663 of same work, are too coarse to be introduced into the mouth; the former being a fraction below fourteen carats, while the latter is still more objectionable, exceeding but little twelve and one-half carats.

Formula No. 1 of the following recipes is a fraction over fifteen carats fine: and No. 2 furnishes a solder eighteen carats fine:—

Formula No. 1.	*Formula No. 2.*	
6 dwts. gold coin,	Gold coin,	30 parts.
30 grs. silver,	Silver,	4 "
20 grs. copper,	Copper,	1 "
10 grs. brass.	Brass,	1 "

In the reduction of gold for solders, Dr. Dorrence recommends the use of what he calls "solder alloy." This is derived from the following formula:—

1 part pure silver,
2 parts pure zinc,
3 parts pure copper.

The copper and silver are melted without flux, in a clean crucible which is well lined with borax; the zinc is then added in small quantities as rapidly as may be without chilling the molten mass so that it loses its fluidity, meanwhile stirring it with a clay pipe-stem or rod, or a white-wood stick, until the profuse fumes of the burning zinc just pass off, when pour immediately into an ingot mold, or into clean water in a clean wooden pail. The metals entering into the composition of this solder alloy should be absolutely pure, especially should they be free of arsenic, antimony, cadmium, etc., in which case not only the alloy, but gold and silver solders made from it, will be tough and easy-flowing. Inasmuch as the zinc, in compounding the alloy, has not been protected from oxidation, if it has been cast at the proper moment, it will be found present in about its combining weight. Both gold and silver solders made with this alloy will, as has been stated, be found very tough, and easy-

flowing, the range of proportion most desirable being, for gold solder, from 20 to 12 carats, or from 15 to 50 per cent. of alloy. Dr. D. very properly says, however, that the 12 carat or 50 per cent. solder is too coarse for dental work. From 10 to 15 per cent. of the alloy added to gold coin is recommended as a suitable solder in the construction of coin-gold crowns.

Zinc, as a constituent of solders, is used principally with a view of rendering them more fusible without materially debasing them if the proper proportion is observed. Its employment under any circumstances has been objected to by some, on the ground that the alloy is more readily tarnished in the mouth, is more brittle, and that it furnishes more favorable conditions for galvanic action. These objections only hold good when zinc is used in excess. When employed in quantities sufficient only to make the gold flow readily and evenly at a diminished heat, it is claimed that the base metal used in these alloys is chiefly consumed in the process of soldering, leaving a residuum of gold alloy equal, or nearly so, in purity to solder not so contaminated. If such is the case, they are acceptable alloys for soldering purposes, inasmuch as it is not only desirable to have an easy-flowing solder, but one which shall have as little affinity as possible for acids often found associated with the fluids of the mouth. Care should be taken to add no more zinc than is necessary to make the solder flow freely under a heat that may be safely applied without danger of melting the pieces to be united.

Method of reducing Gold to a lower or raising it to a higher standard of Fineness, and of determining the Carat of any given Alloy.—In the process of compounding gold for dental purposes, the manipulator should always aim at exactness in the quantity and relative proportions of the reducing components, and should be able to determine precisely the purity of the metals he employs. Gold alloys are too often arbitrarily compounded, and used without any adequate knowledge of their qualities or properties; and formulas, taken on trust, are employed without any certain knowledge of the quality of the alloys they produce.

That we may know certainly the quality of the gold alloys used in the laboratory without resorting to the inconvenient

process of analysis or assaying, they should always be made either from pure gold or gold coin, the standard of these being definitely fixed. But as the process of procuring pure gold is somewhat tedious and troublesome, gold coin is very generally employed for the purpose. The amount of alloy necessary to reduce either pure or coin gold to any particular standard, and the method of ascertaining the carat or fineness of any given alloy, may be readily determined by a few simple rules. The following practical remarks on the method are taken from an article on "Alloying of Gold,"* by Professor G. Watt.

"1. **To Ascertain the Carat of any given Alloy.**—The proportion may be expressed as follows:—

"As the weight of the alloyed mass is to the weight of gold it contains, so is 24 to the standard sought. Take, for example, Harris's No. 3 gold solder:—

Pure gold,	6 parts.
" silver,	2 "
" copper,	1 "
Total,	9

"The total proportion would be expressed thus:—

$$9 : 6 :: 24 : 16.$$

"From this any one can deduce the following:—

"RULE.—Multiply 24 by the weight of gold in the alloyed mass, and divide the product by the weight of the mass; the quotient is the carat sought.

"In the above example, 24 multiplied by 6, the quantity of gold, gives 144, which, divided by 9, the weight of the whole mass, gives 16. Hence, an alloy prepared as above is 16 carats fine.

"As another example, under the same rule, take Harris's No 1 solder:—

22 carat gold,	48 parts.
silver,	16 "
copper,	12 "
Total,	76

* *Dental Register of the West*, vol. x, p. 396.

"Now, as the gold used is but 22 carats fine, one-twelfth of it is alloy. The one-twelfth of 48 is 4, which subtracted from 48 leaves 44. The statement then is:—

76 : 44 :: 24 : 13.9.

"This solder, therefore, falls a fraction below 14 carats.

"2. **To Reduce Gold to a Required Carat.**—The proportion may be expressed as follows:—

"As the required carat is to 24, so is the weight of the gold used to the weight of the alloyed mass when reduced. The weight of gold subtracted from this gives the quantity of alloy to be added.

"For example, reduce 6 ounces of pure gold to 16 carats.

"The statement is expressed thus:—

16 : 24 :: 6 : 9.

"Six subtracted from 9 leaves 3, which is the quantity of alloy to be added. From this is deduced the following:—

"RULE.—Multiply 24 by the weight of pure gold used, and divide the product by the required carat. The quotient is the weight of the mass when reduced, from which subtract the weight of the gold used, and the remainder is the weight of alloy to be added.

"As another example under the same rule, reduce 1 pennyweight of 22 carat gold to 18 carats.

"As the gold is only 22 carats fine, one-twelfth of it is already alloy. The 1 pennyweight, therefore, contains but 22 grains of pure gold. The statement is, therefore, thus expressed:—

18 : 24 :: 22 : 29⅓.

"Twenty-two subtracted from 29⅓ leaves 7⅓. Therefore, each pennyweight of 22 carat gold requires 7⅓ grains of alloy to reduce it to 18 carats.

"3. **To Raise Gold to a Higher Carat.**—This may be done by adding pure gold or a gold alloy finer than that required. The principle of the rule may be set forth in the following general expression:—

"As the alloy in the required carat is to the alloy in the given carat, so is the weight of the alloyed gold used to the weight of the reduced alloy required. The principle may be practically applied by the following:—

"RULE.—Multiply the weight of the alloyed gold used by the number representing the proportion of alloy in the given carat, and divide the product by that representing the proportion of alloy in the required carat; the quotient is the weight of the mass when reduced to the required carat by adding fine gold.

"To illustrate this, take the following example:—

"Raise 1 pennyweight of 16 carat gold to 18 carats.

"The numbers representing the proportions of alloy in this example are found by respectively subtracting 18 and 16 from 24. The statement is, therefore—

$$6 : 8 :: 1 : 1\tfrac{1}{3}.$$

from which it follows that to raise 1 pennyweight of 16 carat gold to 18 carats, there must be one-third of a pennyweight of pure gold added to it.

"But suppose that, instead of pure gold, we wish to effect the change by adding 22 carat gold. The numbers, then, respectively representing the proportions of the alloy would be found by subtracting, in the above example, 16 and 18 from 22, and the statement would be.

$$4 : 6 :: 1 : 1\tfrac{1}{2}.$$

"It follows, then, that to each pennyweight of 16 carat gold a half pennyweight of 22 carat gold must be added to bring it to 18 carats.

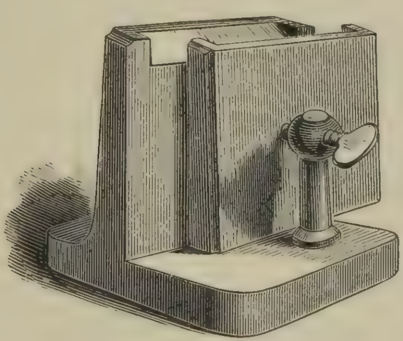
"By the above rules, we think the student will be able, in all cases, to calculate the fineness or quality of his gold, and to effect any reduction, whether ascending or descending, which he may desire."

CHAPTER VI.

METHOD OF CONVERTING GOLD ALLOYS INTO THE REQUIRED FORMS FOR DENTAL PURPOSES.

Manner of Procuring an Ingot.—The gold to be molded in the form of ingot is put into a clean crucible lined on the inside with borax, and placed in the furnace. When the contained metals are perfectly fused, the crucible should be removed from the fire with a pair of tongs, and the contents poured quickly but carefully into the ingot molds; the latter being placed conveniently near the mouth of the furnace, as the molten metals soon become chilled on exposure to the open air.

FIG. 49.



Before pouring, the moulds, if made of iron, should be moderately heated and oiled, or coated with lamp smoke by holding their inner surfaces over the flame of an oil lamp or gas jet.

Ingot molds are constructed of various substances, but those in most common use are formed of iron, and, for gold, are generally about two inches square and from one-eighth to one-sixth of an inch thick (Fig. 49). They should be slightly concave on their inner surfaces, to compensate for the greater shrinkage of the gold in the center than at the margins of the ingot.

Soapstone is sometimes employed for the same purpose, and is preferred by some. Molds made from this substance should also be warmed and oiled before pouring the metals.

Molds are also made from charcoal, which is highly recommended for the purpose, though it requires to be frequently renewed. Prof. Gorgas, in commenting on the relative fitness or value of the several substances mentioned, says: "Iron is perhaps the most convenient; soapstone gives, with the same gold, a tougher ingot; whilst with charcoal, the greatest toughness of metal is obtained, so far as the nature of the ingot mold can modify it. Pig-iron, from the same furnace, run into iron molds, may be white and brittle; or into sand molds, gray and less brittle; or into charcoal, dark gray and soft. Some such molecular arrangement of gold, due to its manner of cooling, is probably the correct explanation of the fact that a charcoal mold yields, other things being equal, a tougher ingot than iron."

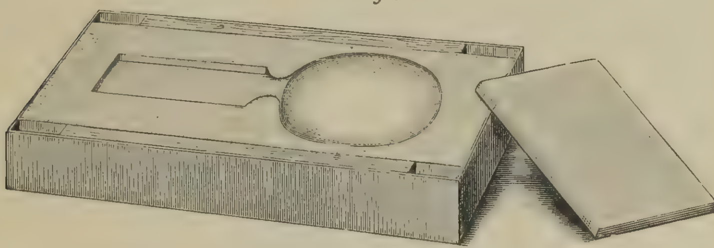
Charcoal ingot molds may be very easily and quickly made as follows: Selecting a close-grained, compact piece, of suitable size, cut through it with a saw, and then rub the divided surfaces together until perfect coaptation is secured. The required size and shape of the mold is then cut out in one section of the block; or a strip of sheet iron, a little broader than the required thickness of the ingot, being bent into proper form, is placed between the two pieces, with the edges partially imbedded, and the whole secured in place by binding with wire, or with the use of clamps.

Asbestos Molds.—Comparatively inexpensive, and at the same time more convenient and durable contrivances designed for the same purpose, combining both crucible and mold, and embracing the special advantages claimed for charcoal, may be obtained at the dental depots. One of the simplest forms of this kind is the asbestos melting and ingot block shown in Fig. 50. When in use, place a piece of charcoal over the bowl-shaped portion of the ingot block, as it facilitates heating the metal. The small asbestos slab being placed in position to complete the mold, and retained in place by clamping, the metal, when sufficiently fused, is poured into the mold by tipping the block. The bowl or crucible has a thin coating of whiting, to

prevent borax or other flux from adhering. Should this occur, however, rub a little moist whiting in the bowl. The sides of the block are encased in strips of wood, to protect the hands from heat.

Carbon Molds.—A very ingenious, convenient and useful

Fig. 50.



apparatus, combining crucible and ingot mold, by the use of which ingots of gold, silver, etc., may be quickly obtained without the use of a furnace, is shown in Fig. 51. The crucible is of molded carbon, and is supported in position by an iron side-

Fig. 51.

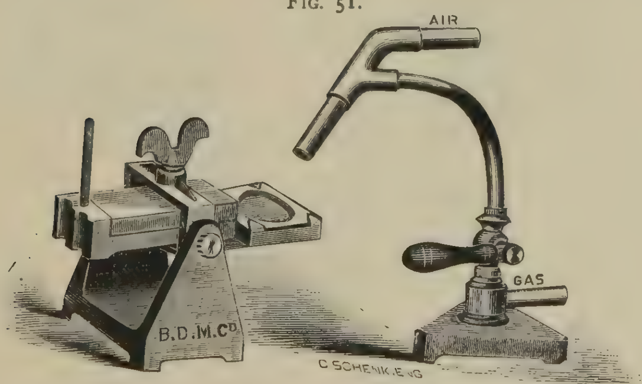


plate. A clamp holds crucible and ingot mold in position, swiveling on a cast-iron stand.

The metal to be melted is placed in the crucible, and the flame of the blowpipe directed on it until it is perfectly fused. The waste heat serves to make the ingot mold hot, and the whole is

tilted over by means of the upright handle at the back of the mold. With this simple instrument, a sound ingot may be obtained at any time in about two minutes.

Aside from the greater convenience and cleanliness, as compared with the older method in which draft-furnace heat is used, there is great economy of time in the use of the last named appliance combining crucible and mold, since an ingot may be thus obtained, with the use of the bellows blowpipe, in from two to three minutes. It is suitable for melting from two to four ounces of gold or silver.

It not infrequently happens that, at the first pouring, the metals arrange themselves in the ingot in accordance with the

FIG. 52.

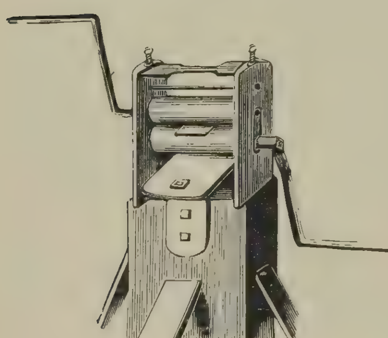
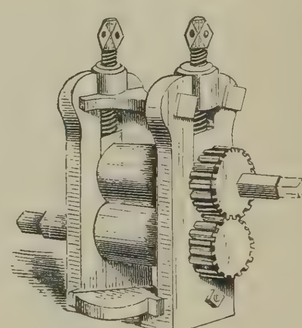


FIG. 53.



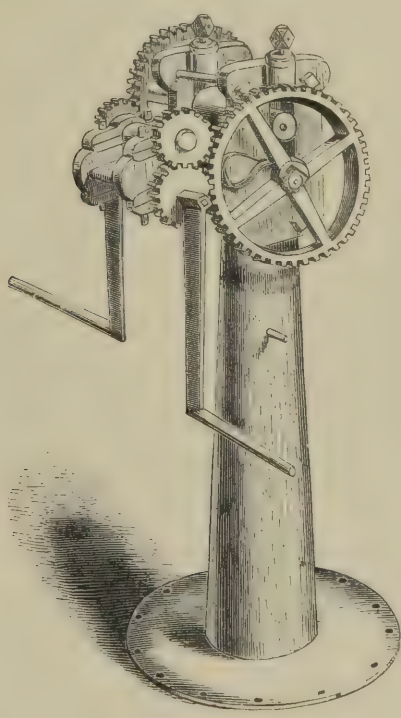
density of the several components, those of greater specific gravity passing to the bottom, and the lighter metals remaining above. Whenever this occurs, the ingot must be broken into pieces and remelted; this should be repeated, if necessary, until the alloy assumes a perfectly homogeneous appearance. It should then be annealed in hot ashes, which softens the gold and removes the adhering grease.

Forging.—Before laminating, the ingot should be reduced somewhat in thickness by placing it on an even-faced anvil or other equally smooth and resistant surface, and subjecting it to repeated blows with a tolerably heavy hammer. It should be frequently annealed, and the process of forging continued, al-

ternately hammering and annealing, until the ingot is reduced one-half or more in thickness.

Laminating or Rolling.—The reduced ingot, well annealed, is next laminated or spread out into a sheet of greater or less thinness by passing it repeatedly between two strong, highly-polished cylindrical steel rollers. The mills used for the purpose are variously constructed, the plainest forms (Fig. 52) being very

FIG. 54.



simple in their mechanism, while others, or geared mills, are more complicated, and are constructed with a view to a greater augmentation of power, and precision and certainty of action. The latter (Figs. 53, 54), if of approved pattern, materials, and manufacture, are, upon the whole, more economical and reliable than the cheaper varieties. The rollers, for the purposes of the dentist, should be from three to four inches in length.

In laminating, the rollers should first be adjusted equidistant at both ends, and this uniformity, as they are approximated from time to time, should be preserved throughout. At every passage of the gold bar between the rollers, the distance between the latter should be diminished, care being taken that the approximation be insufficient to clog or impede the free action of the mills. The gold, which, in time, becomes hard and brittle, and liable to crack in the mills, should be frequently and well annealed by bringing it to a full red heat; this restores the pliancy of the gold and facilitates the operation in the press.

When the ingot has been extended in one direction as far as may be desired, it should always be re-annealed before turning it in the mills; a neglect of this precaution will seriously interfere with the working of the gold by twisting or doubling the plate upon itself; and in some instances, provided the gold has not been well annealed throughout the operation, or is in any considerable degree unmalleable, the plate will be torn across and rendered unfit for use.

A thin or retreating edge may be given to the plate at any desired point or points by passing such portions part way between the rollers and withdrawing; repeating this, with the rollers brought a little nearer to each other every time the plate is introduced between them, and decreasing the distance the plate passes each time until it is reduced to as thin an edge as may be desired.

Standard Gauge Plate.—The degree of attenuation obtained by rolling is determined by what is called a *gauge plate* (Fig. 55). This instrument is usually circular or oblong in form, and is marked at intervals on its edge by cross-cut grooves or fissures, which successively diminish in size and are indexed by numbers ranging from 5 to 36. The sizes of the grooves diminish with the ascending numbers. During the operation of rolling, the plate should be tested, from time to time, by the gauge, to determine when it has undergone sufficient attenuation.

Thickness of Gold Plate required as a Base for Artificial Dentures.—In prescribing the thickness of plate proper for the purpose indicated, no estimate can be given that will apply to all cases, as certain conditions of the mouth, to be mentioned here-

after, will suggest some modifications in this respect. Usually, however, plate for *entire upper sets should correspond in thickness with number 26 of the gauge plate ; for the lower jaw, number 24 may be used ;* while for partial upper pieces, an intermediate number may be chosen, unless atmospheric-pressure plates are used, when the number recommended for full upper sets may be employed.

Thickness of Plate for Clasps, Stays, etc.—Plate for these purposes should usually correspond with number 22 of the gauge ; a less amount of substance, as before stated, being required when the alloy has incorporated with it a small proportion of platinum.

FIG. 55.

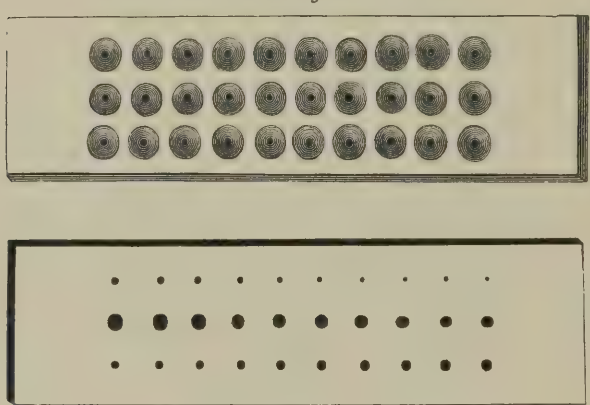
Reduction of Gold Solders into Proper Form for Use.—The method of converting gold solders into the form of plate does not differ from that already described in the manufacture of plate as a base, except that when zinc or brass is used, the latter should be added after the other constituents are completely fused, and then instantly poured, to prevent undue wasting of the base metals by a too protracted heat.

The solder should be reduced to plate somewhat thinner than that used for upper sets, 28 of the gauge plate. It is customary sometimes to roll the solder into very thin ribbons, but this is objectionable for the reason that a greater amount of the alloy-

ing metals, being exposed in a given surface to the action of the heat in soldering, are burnt out or oxidated, which interrupts the flow and weakens the attachment between the solder and plate.

Method of Obtaining Gold Wire.—To convert gold or its alloys into the form of wire, the operator should be provided with a draw plate, a vise, and a pair of hand pincers. A draw plate (Fig. 56) is an oblong piece of steel pierced with a regular gradation of holes, or a series of progressively diminishing apertures, through which the gold bar, reduced to a rod, is forced and made to assume the form and dimensions of the hole

FIG. 56.



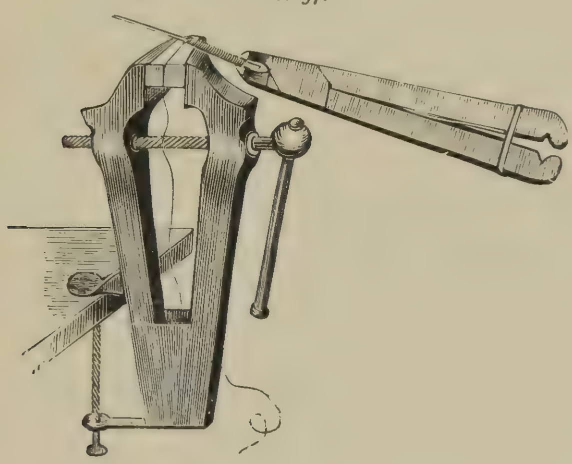
through which it is last drawn. The holes are formed with a steel punch, and are enlarged on the side where the wire enters and diminish with a gradual taper to the other side. A *draw bench* is sometimes employed in extending the wire, the power being applied by a toothed wheel, pinion, and rack-work, and is moved by the hands of one or two persons. For the purposes of the dentist, however, it will be sufficient to fix the draw plate securely between the jaws of a bench vise, and, by seizing hold of one end of the gold rod with a strong pair of clamps or hand pincers, serrated or cut like a file on the inside of the jaws, the wire may be drawn steadily through the plate, passing from the

larger to the smaller holes until a wire of the required size is obtained.

In drawing the wire the motion should be steady and uniform, for if drawn interruptedly or by jerks, the wire will be marked by corresponding inequalities. The gold rod should also be annealed from time to time, and the holes kept well greased or waxed.

The process described above will answer equally well in reducing any of the ductile metals to wire, as silver, copper, platinum, etc., so that any further description of the method, in connection with these metals, will be unnecessary.

FIG. 57.



Method of Constructing Spiral Springs.—Inasmuch as spiral springs have been, to a great extent, superseded by more approved agencies employed in the retention of artificial teeth in the mouth, and as all the principal dental furnishing houses are supplied with these appliances already prepared for use, it does not seem necessary to enter into a description of the various apparatuses used in making them.

The following simple contrivance will meet the limited requirements of those who are obliged or prefer to manufacture their own springs. The wire, obtained as already described, is held

between two blocks of wood fastened between the jaws of a bench vise, as shown in Fig. 57. By means of a small hand vise, one end of the wire is clamped to a uniformly cylindrical and well-tempered steel rod or wire, four or six inches long, and about the size of a small knitting-needle, and which being made to revolve while resting on the blocks of wood, the wire is wound firmly and compactly around it, producing a uniform coil.

CHAPTER VII.

SILVER.

Ag (Argentum).

General Properties of Silver.—Pure silver, when planished, is the brightest of the metals. Fused, or in the form of ingot, its specific gravity is 10.47; but when hammered or condensed in the coining press, its density is increased and its specific gravity becomes 10.6. It is remarkably laminable and ductile, yielding leaves not more than $\frac{1}{100000}$ of an inch thick, and wire 400 feet of which may be drawn weighing but a single grain. It exceeds gold in tenacity or cohesion, but is inferior to platinum in this respect. A silver wire .078 of an inch in diameter will sustain a weight of 187.13 pounds. Fine silver is unaffected by moisture or pure atmospheric air, but is readily tarnished with a film of brown sulphuret by exposure to sulphuretted hydrogen. The sulphuret of silver thus formed may be easily removed by rubbing the metal with a solution of *chameleon mineral*, prepared by calcining equal parts of black or peroxid of manganese and nitre. *Unlike gold and platinum, it is readily soluble in nitric acid, this and sulphuric acid being the only simple ones that dissolve it.* **Silver fuses** at an extreme red heat, generally estimated at 1873° Fahrenheit. It becomes very brilliant when heated; boils and vaporizes above its fusing point; and when cooled slowly its surface presents a crystalline appearance.

Alloys of Silver.—Silver combines readily with most metals, forming compounds of variable degrees of malleability, ductility, density, etc.

Tin, zinc, antimony, lead, bismuth, and arsenic render it brittle. A very minute quantity of tin is fatal to the ductility of silver. Silver does not easily combine with iron, although the two metals may be united by fusion. Gold, copper, platinum, iridium, steel, manganese, and mercury also form alloys with silver.

An alloy of nine parts of silver and one part of copper is the Government standard of the United States coinage since 1837. To this, three-cent pieces form an exception; these being composed of three parts silver and two of copper. The coins of silver having a greater average fineness than those of our own country are Brazil, Britain, Chili, France, Greece, Hindostan, Persia, Portugal, Rome, and Tuscany. A common impression prevails that the Mexican silver coin contains more than an average percentage of pure silver, and it is therefore sought after on account of its supposed purity. This is true of some pieces coined at different periods, but the average fineness of the Mexican, as well as the Spanish coins, falls below that of the United States mints.

Refining Alloys of Silver.—The following accounts of the manner of obtaining pure, or nearly pure, silver from alloys of that metal by the dry, and wet or humid methods, are given by Prof. Essig in his treatise on "Dental Metallurgy:"—

Dry Method.—"The dry method or assaying process consists in forming an alloy of the silver with lead, and is especially applicable to ores and the sweepings of the dentist's laboratory. The specimen to be treated is heated with from twelve to thirty times its weight of granulated lead, in a bone-ash cupel, which is placed in a muffle so arranged that a current of atmospheric air may pass freely over the vessel and oxidize the lead. This oxid of lead, being quite fusible, combines with any base metal present and oxidizes it, uniting subsequently with the oxid as a fusible slag, while the gold or silver will be held by the unoxidized portion of the lead. In the treatment of specimens of alloy, such as plate or coins, a quantity of the specimen is accurately weighed and mixed with from four to five times its weight of pure granulated lead. It is then placed in the cupel and exposed to heat, as above described, until all the lead is oxidized or converted into litharge, when the remaining button assumes the brilliant appearance of surface to which allusion has been previously made, denoting that the base metals or oxidizable constituents have been oxidized and taken up by the lead oxid. This button is then to be weighed by means of a delicate assay balance, and the loss of weight denotes the amount of alloy that was present.

Wet Method.—" Pure silver, which is reckoned as 1000 fine, may be obtained from standard or other grades of silver by dissolving them in nitric acid slightly diluted with water, the solution being much facilitated by exposure to gentle heat. If gold be associated with the alloy it will be found at the bottom of the vessel, in which case it will be necessary to use a siphon to remove the argentic nitrate solution. The silver is now to be precipitated in the form of chlorid by the addition of an excess of common salt. When all has subsided the liquid is carefully poured off, and the chlorid thoroughly washed, to remove all traces of acid. The chlorid is then placed in water acidulated with hydrochloric acid (an ounce of chlorid requiring six to eight ounces of water) and pieces of clean wrought-iron put in it, when a copious evolution of hydrogen follows, which, uniting with the chlorin of the argentic chlorid, liberates metallic silver. The latter should not be disturbed until the last particle of it is thus reduced, when it will be found to be a spongy mass. The undissolved iron should now be carefully removed, the ferrous and ferric chlorid carefully decanted, and the silver washed in hot water containing about one-tenth its bulk of hydrochloric acid. This is repeated several times, and finally the silver is again thoroughly washed with pure hot water. The silver, after drying, is then ready for melting, and if care has been observed in the process it will be found to be of a fineness of 999.7 parts in 1000, the 0.3 of impurity present being due to traces of iron. The chlorids may be acidulated with sulphuric acid, and reduced with zinc instead of iron.

" **Another method** of precipitating silver in the metallic form consists in placing a sheet of copper in a solution of argentic nitrate. The metal is thrown down in a crystalline form. Silver thus obtained is never free from traces of copper.

" Pure silver can only be obtained from samples of a lower grade by fusing the pure chlorid with sodium carbonate. The reaction is shown in the following equation :—

$$2AgCl + Na_2CO_3 = Ag_2 + 2NaCl + O + CO_2.$$

Owing to the copious evolution of carbonic acid gas which takes place during the decomposition, some of the silver may be

thrown from the crucible, and loss may occur by the absorption by the crucible of some of the fused chlorid. To avoid this, the sides of the vessel should be coated with a hot saturated solution of borax.

"A composition of 100 parts of argentic chlorid, 70.4 of calcic carbonate (chalk), and 4.02 of charcoal, has been recommended as a means of obtaining pure silver. This mixture is heated to dull redness for thirty minutes, and then raised to full redness; carbonic acid and carbonic oxid are given off; the calcic chlorid is converted into calcic oxychlorid, underneath which, in the bottom of the crucible, will be found the button of pure silver."

Reduction of Silver to the Required Forms for Dental Purposes.—Owing to the very soft and flexible nature of silver in its pure state, it is usual, when converting it into plate or other forms for use, to employ an alloy of the metal. Hence silver coins, which are made harder by the copper they contain, are generally selected for the purpose. The employment of silver, thus debased, as a base for dental substitutes is regarded by many as unsafe and injudicious. Although the influences of an alloy so readily acted upon as this by the various agents which affect it chemically cannot always be certainly predicted in every case, yet no reasonable doubt can be entertained but that, under the favoring conditions which usually exist in the mouth, the evils accruing, directly and indirectly, to the organs of the mouth, and through them to the general system, are positive and undoubted. If used at all, therefore, it should be alloyed with the least practicable amount of copper, or, what is better, pure silver should be reduced with platinum alone, in sufficient quantities to impart to the plate an adequate degree of strength and elasticity. The tendency of silver to tarnish in the mouth when alloyed with copper may be diminished by boiling the finished piece in a solution of cream of tartar and chlorid of soda, or common salt, or by scrubbing it with aqua ammonia, which removes the superficial particles of copper and exposes a surface of fine silver. When platinum is introduced as the sole alloying component, the purity of the silver is not only preserved, but the alloy is less easily acted on chemi-

cally, while the plate derived from it is rendered sufficiently inflexible and elastic. From three to five grains of platinum may be added to one pennyweight of pure silver.

On account of the strong affinity of sulphur for silver, the fuel most proper to be used in melting it is charcoal. The various processes employed in the conversion of silver into the required forms for use are similar to those described for gold, and need not be recapitulated.

Formulas for Silver Solders.—Silver solders are usually composed of silver, copper, and zinc in variable proportions. Alloys formed from the following formulas are such as are generally employed in soldering silver plate derived from the coins of that metal. Three-cent pieces, composed of two parts silver and one of copper, may be used for the same purpose:—

Formula No. 1.

Silver,	66 parts.
Copper,	30 "
Zinc,	10 "

Formula No. 2.

Silver,	6 parts.
Copper,	2 "
Brass,	1 part.

When the material to be united is composed of pure silver and platinum, silver coin alloyed with one-tenth zinc may be used as a solder.

In compounding silver solders, the silver and copper should be first melted, and the zinc or brass afterward added, when they should be quickly poured, to prevent undue waste by oxidation of the more fusible component. The ingot, when cold, should be rolled into a plate a little thicker than that recommended for gold solder.

CHAPTER VIII.

PLATINUM.

Pt.

General Properties.—Platinum is a grayish-white metal, resembling, in some measure, polished steel. It is harder than silver, and has a density greater than any other known metal, its specific gravity being 21.25. It remains unaltered in the highest heat of a smith's forge, and can only be fused by means of the oxy-hydrogen blowpipe and galvanism. A white heat does not tarnish it, nor is it in any way affected by exposure, either in the air or water. It is insoluble in any of the simple acids; *nitro-muriatic acid* (aqua regia) *being the only one that dissolves it.* It is sufficiently malleable to be hammered into leaves so thin as to be blown about by the breath. It may be drawn into wire two-thousandths of an inch in diameter, and a still greater attenuation may be obtained by coating the wire with silver, drawing it out, and dissolving off the latter metal. It expands less by heat than any other metal, and is much inferior to gold, silver, and copper as a conductor of electricity. While it does not oxidize in the air at any temperature, nor is soluble in any one acid, if heated to redness in the air, in contact with caustic alkalies or alkaline earths, a hydrated oxid is formed which combines with the alkaline base in a similar manner to palladium.

Platinum is very soft and flexible, and when rolled into thin sheets, say 28 or 30 of the gauge-plate, and well annealed *at a strong white heat for eight or ten minutes*, it may be readily forced into all the inequalities of a zinc die without producing any appreciable change in the face of the latter.

The Fusing Point of platinum is above 3500° Fahrenheit, to reach which, in the laboratory, it is necessary to employ the oxy-hydrogen blowpipe.

The following interesting and practical observations on the method of melting platinum scraps are by E. A. L. Roberts.

By the process of welding, the operator will be enabled to re-convert his waste scraps of platinum into convenient forms for use, and of which he could not otherwise avail himself, on account of the infusible nature of this metal in its uncombined state:—

"Platinum used by dentists should be soft, tough, and without flaws. These qualities can be attained only by thorough melting and welding. The welding must be done at a white heat. When the surface is cool enough to be visible, the metal is too cool to be welded, and every blow is injurious, because it has a tendency to shatter and shake it to pieces. The necessary delicacy of this process and the uncertainty of success has led some writers to declare that platinum is incapable of being welded. The platinum must be perfectly clean, and must be heated in a muffle. When welded, the metal should be handled with tongs plated with platinum, and hammered with a clean hammer on a clean anvil, both of which should be as hot as possible without drawing the temper of the steel. The hammer used in welding should weigh about a pound, to prevent drawing the metal; but when welded the metal may be forged with a heavier hammer.

"The scraps or sponge should be condensed in a square mold, very compactly, two pieces of which, weighing from ten to twenty ounces, may be put in a muffle together. When the heat becomes so great that on opening the door the metal becomes invisible, bring one of the pieces, in the tongs, quickly to the anvil, give it three or four quick, sharp blows, in rapid succession. Return the piece to the muffle, and proceed with the other piece in like manner, and thus alternately until both are thoroughly welded.

"Platinum should never be thrown into water while hot, as that tends to make it crystallize. It should be thoroughly hammered, which makes it tough and fibrous.

"The following process gives the best results in melting this metal. Condense the scraps, sponge, or filings in an iron mold. Lay the condensed mass on a concave fire-brick, and heat it to whiteness. Take the brick from the muffle, and place it in a sheet-iron pan, coated with plaster and asbestos. The pan should be deep enough and broad enough to catch all globules

8

and other loose particles of the metal. Place it under the jet of the oxy-hydrogen blowpipe in the following manner:—

"The pan is provided with a handle, opposite to which is a ring, which is to be attached to an iron hook and rod, suspended from the ceiling by a slip of india-rubber, which enables the operator to hold the pan conveniently at any distance from the jet of the burning gases. The hydrogen is first lighted, and gives a powerful flame, but as the oxygen combines with it, the flame subsides into an intense focus of heat, in which the metal is soon brought to a state of fusion. Begin at one end and melt along toward the other, till the whole is fused in one mass. The platinum in this condition, when cool, is quite crystallized and sonorous. It breaks very easily, like spelter-zinc. Heat it very hot and forge it. A continuation of this process renders it soft, tough, and fibrous. When reduced to the width desired, and to the thickness of one-fourth of an inch, it should be made very hot and passed instantly through the rollers."

Use for Dental Purposes.—Platinum, in mechanical practice, is chiefly employed as a base for continuous-gum work; as a coloring ingredient of porcelain; for pins for attaching mineral teeth; for backings, and dowels in crown- and bridge-work; and, to a limited extent, in some of the minor operations of the shop.

Solder for Platinum.—Pure gold is the only proper solder for this metal.

Alloys of Platinum.—Platinum unites with most of the base metals, forming alloys of variable degrees of hardness, elasticity, brittleness, color, fusibility, etc., but their practical value to the dentist is not sufficient to justify a separate description of their properties.

Alloyed with *gold* it forms a straw-colored alloy, the shade depending on the quantity of gold added. *Silver* hardens it, the resulting alloy being unaffected by sulphur.

Platinoid Metals.—The platinoid metals, palladium, iridium, osmium, rhodium, and ruthenium, are native contaminations, the alloys of these metals having a close general resemblance to platinum.

Among the platinoid metals, palladium and iridium are the

only ones that have been used for dental purposes, and these only to a limited extent. Palladium is of a steel-gray color, and when planished, is a brilliant steel-white metal, not liable to tarnish in the air. Though closely resembling platinum, it may be readily distinguished from the latter metal by the following tests: 1. It has little more than one-half the density of platinum. 2. If a piece of it is heated to redness, it assumes a bronze-blue shade, of greater or less intensity, as it is cooled more or less slowly; but if it is suddenly chilled by immersing it in cold water, it instantly resumes its original luster. 3. When a drop of the tincture of iodin is let fall upon its surface and evaporated over the flame of a lamp, a black spot remains, which does not occur with platinum. Palladium melts at about the heat required to fuse malleable iron, and is the most fusible of the platinoid metals. It is soluble in nitric acid, but its best solvent is nitro-hydrochloric acid.

Palladium, being very costly, and possessing no properties that specially recommend it for dental use, is but little employed in prosthetic practice.

Iridium, though generally found associated with platinum, osmium, and other allied metals, sometimes occurs native and nearly pure. Like platinum, it is very refractory when exposed to high temperatures, and can only be fused by the oxy-hydrogen blowpipe or by the heat of the voltaic current. An alloy of one-fifth platinum and four-fifths iridium has been met with in octahedral crystals, whiter than platinum, and of specific gravity 22.66. When native platinum is dissolved in nitro-hydrochloric acid, black scales remain behind, which are composed of iridium and osmium. These metals may then be separated by one of the methods in use, and the iridium is obtained in a gray metallic powder, resembling spongy platinum. Iridium is very hard, white, and brittle, and has a specific gravity of 21.15. None of the acids attack the pure metal, but when alloyed with platinum it is readily dissolved by aqua regia or nitro-hydrochloric acid. If heated in a finely divided state in the open air, iridium absorbs oxygen; it is also oxidized by niter and caustic potash.

The extreme hardness and consequent rigidity of iridium

renders it, in its unalloyed state, practically unfit for base plates on account of the great difficulty of swaging it into proper form. This, however, may be accomplished in certain cases, as in partial pieces, with the use of zinc dies and counters; and in these cases it is desirable on account of the increased strength its property of hardness imparts to the plate. It may be used to advantage, however, alloyed with platinum, a small quantity imparting to the latter increased stiffness and elasticity.

CHAPTER IX.

ALUMINUM.

Al.

Derivation.—Aluminum is the metallic basis of alumina, the latter being the characteristic ingredient of common clay. It is only within the past few years that the attention of chemists has been directed to the production of this remarkable metal, with a view to its general introduction into commerce and the arts. Prior to the researches of M. Deville, who, under the patronage of the then Emperor of the French, commenced his researches in 1854 for the production of this metal on a large scale, the small quantities produced, and the corresponding exorbitant prices it commanded, rendered it entirely unavailable for other purposes than merely scientific experiment. The improvements in the methods of obtaining it, however, which have been more recently introduced, have rendered its production more economical, and it is now supplied in much larger quantities, and at a corresponding reduction in the cost of the metal.

The following account of the properties of this metal is taken from a paper read before the Society of Arts, London, by its secretary, P. Le Neve Foster. It embodies a very complete description of the properties of this remarkable metal:—

General Properties.—"One of the most striking properties of aluminum is its extreme lightness, its specific gravity being 2.6, nearly that of glass, whilst that of platinum is 21.5, gold 19.5, copper 8.96, zinc 7.2, tin 7.3.

"The metal is malleable, ductile, almost without limit; it can be reduced to very thin sheets or drawn into very fine threads. Its tenacity, though superior to that of silver, is less than that of copper; but no very accurate experiments have been made in this respect.

"When pure it is about as hard as silver. Its elasticity is not great. It files readily, and is said not to injure the file. It con-

ducts electricity with great facility, so that it may be considered as one of the best conductors known, almost equal in this respect to silver, and more than eight times a better conductor than iron. It melts at a temperature a little above that of zinc, between zinc and silver. In its chemical qualities it would seem to take an intermediate rank between what are termed the noble metals and the common metals, being, as Deville states, one of the most unalterable of metals.

"It might be imagined that it would as readily reassume its oxygen as it parted with it with difficulty when in its state of oxid. This, however, is not the case; it appears to be as indifferent to oxygen as either platinum or gold. In air and in oxygen it undergoes no sensible alteration, and it even resists it at the highest temperature which Deville could produce in a cupelling furnace, a temperature higher than that employed in assaying gold. Water has no action, according to Deville, on aluminum, neither at its ordinary temperature, nor when boiling, nor even upon the metal at a low, red heat, near its melting point. According to Professor Crace Calvert, this statement must be received with some degree of caution, as in experiments he has made he considers that oxidation does take place slowly when the metal is immersed in water for any considerable length of time. It is not affected by sulphur or sulphureted hydrogen, like silver, nor is it acted upon to any considerable degree by any of the oxy-acids in the cold; nitric acid, whether strong or weak, at its ordinary temperature in no way affects it, though when boiling it acts upon it slowly. Small grains of aluminum, plunged in sulphuric acid for three months, remained apparently unaltered. The vegetable acids, such as acetic, oxalic, and tartaric acids, have scarcely any effect on it at all. The true solvent of the metal is hydrochloric acid, which attacks it rapidly. It appears to resemble tin when brought into contact with hydrochloric acid and the chlorids. Its absolute harmlessness permits of its being employed in a vast number of cases where the use of tin would not be desirable on account of the extreme facility with which that metal is dissolved in the organic acids.

"Figuier, in his scientific *Year Book*, states that the caustic alkalies, potash, and soda, and even ammonia, dissolve aluminum

sensibly. He also states that common salt and acetic acid (vinegar), especially when mixed, attack and dissolve aluminum. He adds, that the mixture of salt and vinegar for seasoning a salad, made in a spoon of aluminum, feebly but inevitably attacks it.

"All these points, however, deserve to be inquired into, as there seems some discrepancy between different writers on them."

Alloys.—"Aluminum, like iron, does not unite with mercury, and scarcely at all with lead. It, however, forms a variety of alloys with other metals. It can be alloyed with iron, and when aluminum becomes cheaper it will be curious to see what effect mixtures of this metal with iron will have upon its quality, whether for good or for evil. It seems to unite readily with zinc, and these have been found to give the best promise as solders for aluminum; but, unfortunately, when melted, neither of them are sufficiently liquid, and do not run readily. The joints will not bear a blow. A variety of alloys with nickel have been made, and that consisting of 100 parts of aluminum and 3 of nickel is found to work readily, and to have gained hardness and rigidity, as compared with the pure metal. The alloys, however, with copper are the most striking; they are light and very hard, and capable of a fine polish. In the same degree that copper adds to the hardness of aluminum, so does the latter, when used in small quantities, give hardness to copper, without, however, injuring its malleability. It renders it susceptible of a fine polish, and, according as the proportions are varied, the color of the alloy becomes deep or pale gold. Alloys of copper with five and ten per cent. of aluminum resemble gold, perhaps, more than any other metallic alloy hitherto employed. They do not tarnish sensibly by exposure to the air. Aluminum can be deposited by the battery, and by the same agent it can be gilt or silvered."

Dental Uses.—For several years past attempts have been made to render aluminum available as a base for artificial dentures, both by the swaging and casting processes, with only partial success. When in the form of plate no suitable solder has yet been discovered by which the several parts of a dental appliance may be securely united, and experiments in casting have not yet proven entirely satisfactory. It is being used to a limited extent,

with rubber attachment, and it is hoped that in the near future, upon further acquaintance with its capabilities, it may prove entirely acceptable for dental purposes.

At the present time its use is rarely attempted, except as a base in connection with rubber or celluloid, the latter substances being employed as a means of attaching teeth by a method similar to that described in another place when gold or silver plate is used.

CHAPTER X.

COPPER, ZINC, LEAD, TIN, ANTIMONY, AND BISMUTH.

COPPER.

Cu (Cuprum).

General Properties.—Copper is one of the metals most anciently known; it is of a brownish-red color, with a tinge of yellow; has a faint but nauseous and disagreeable taste, and imparts, when exposed to friction, a smell somewhat similar to its taste. Its specific gravity ranges from 8 8 to 8.9. It is both malleable and ductile, but excels in the former property, finer leaves being obtained from it than wire. It is inferior to iron in tenacity, but surpasses gold, silver, and platinum in this respect. **The Fusing Point** of copper is about 2000° Fahrenheit.

Alloys of Copper.—Copper unites readily with most metals, forming alloys of great practical value in the arts, but which have but a limited application in dental laboratory processes. Many of these alloys are curious and instructive, as illustrating the singular and unaccountable influence of alloying upon the distinctive properties of the component metals. Copper and tin, for example—the former of which is highly ductile, and the latter equally malleable—when combined in the proportion to form speculum metal (9 C : 1 T), form an alloy distinguished for its extreme brittleness, with a surface hardness almost equal to steel. By increasing the quantity of tin until the compound assumes the proportions constituting gun-metal (C 2 : T 1), the alloy, though neither malleable nor ductile, becomes eminently tough and rigid. Other prominent examples might be given, showing how completely this combining influence defies all calculations in regard to ultimate results. The following summary embraces the names and composition of the more familiar alloys of copper, omitting, as unnecessary in this connection, a description of their individual properties.

Alloys of Copper with Zinc.—*Brass* is an alloy of uncertain and variable composition, consisting usually, however, of two to five parts of copper and one of zinc. Brass melts at 1869° Fahr. *Prince's metal*, and its allied compounds, *Pinchbeck*, *Similor*, and *Manheim gold*, consists of nearly equal parts of copper and zinc. *Mosaic gold* consists of 100 parts of copper and from 52 to 55 of zinc. *Dutch gold*, from which foil of that name was formerly obtained, is formed of 11 parts of copper with 2 of zinc. *Bath metal* is composed of 32 parts of brass and 9 of zinc.

Brass Solder consists of two parts of brass and one of zinc, to which a little tin is occasionally added.

Alloys of Copper with Tin.—*Bell metal* usually consists of 100 parts of copper with from 60 to 63 parts of tin. *Cannon metal* is compounded of 90 parts of copper with 10 of tin. *Cymbals* and *gongs* contain 100 parts of copper and 25 of tin. *Speculum metal* consists of two parts of copper and one of tin.

Copper and arsenic form a white-colored alloy, which, in the proportion of nine parts of copper and one of arsenic, is white, slightly ductile, and is denser and more fusible than copper

German Silver is composed of copper, 40.4; nickel, 31.6; zinc, 25.4; iron, 2.6; but the proportions of the metals of this alloy differ according to the various uses to which this compound is applied.

Babbitt metal is a compound of copper, antimony, and tin, in somewhat varying proportions. The following formula is given by Henry Long Jacob in the *British Journal of Dental Science*:—

Copper,	2 parts
Antimony,	3 parts
Tin,	12 parts

The following method of preparing it is given by the same writer:—

"In preparing this metal, the copper is first melted in a crucible, with about an equal weight of tin (the copper thus fusing much more readily than by itself); a little more of the tin is then added, next the antimony, and lastly the remainder of the tin by degrees, stirring well during the whole of the time; the metal can then be poured into sand molds of any con-

venient form. About a year and a half ago I furnished Mr. Thomas Fletcher with this formula, and I believe it is given in his work on 'Dental Metallurgy.' The melting point of this metal is lower than that of zinc and somewhat higher than that of lead, so that counter-molds of this latter can be readily made to it with proper care. I am under the impression that the original Babbitt metal was said to contain a portion of lead, but this addition was found to be injurious."

ZINC.

Zn (Zincum).

General Properties.—Zinc is a bluish-white metal, possessing considerable luster when broken across. The commercial variety is always impure, containing traces of iron, lead, cadmium, arsenic, carbon, etc. It does not easily tarnish in dry air, but soon becomes dull on exposure to moisture. In the condition in which it ordinarily occurs it is a brittle metal, but may be rendered malleable by annealing it at certain temperatures. This change in its condition is effected by subjecting it to a heat of from 220° to 300° F., at which temperature it may be rolled into sheets, and retain its malleability when cold. The best annealing temperature for zinc is about 245° F. A knowledge of this fact will enable the operator to avail himself of the advantages of this property by annealing his zinc die, by which its liability to crack or part under the hammer is diminished.

The Fusing Point of zinc is about 775° F., and when heated much above this point with contact of air, it burns with a brilliant, greenish-white flame, while woolly-looking flocculi rise from the vessel in which it is being heated and float in the air. The specific gravity of zinc varies from 6.9 to 7.2.

Use for Dental Purposes.—Zinc has been long and almost exclusively employed in the formation of dies used in swaging metallic plates employed in mounting artificial teeth, and experience has very justly accorded to it undisputed pre-eminence above all other unalloyed metals for the purpose. A more particular account of its peculiar fitness for dental purposes will be given under the head of Metallic Dies and Counter-Dies.

LEAD.

Pb (Plumbum).

Properties.—Lead has a grayish-blue color, with a bright metallic luster when melted or newly cut, but it soon becomes tarnished and dull-colored when exposed to the air. The specific gravity of commercial lead, which is usually contaminated with other metals, is 11.352.

The Fusing Point of lead is 617° F. Exposed to a high heat, it absorbs oxygen rapidly, forming on its surface a gray film of protoxid and metallic lead. It is both malleable and ductile, but soft and perfectly inelastic.

Its Use in the Laboratory.—Lead, either in its pure state or when alloyed with certain other metals, serves important purposes in the dental laboratory. In its simple or uncombined state it is useful only in forming counter-dies. Alloyed with antimony in the proportion of ¼ to ⅛ of the latter, with the addition sometimes of very small portions of copper, tin, and bismuth, it forms different grades of *type-metal*, which is harder than lead and very brittle, and is sometimes used for dies; and sometimes, though very rarely, for counter-dies. When type-metal is used as a counter to a zinc die, it is improved for the purpose by adding to it an equal quantity of lead; it may also be used in the form of a die in connection with a lead counter after rough stamping with zinc.

Fusible Alloys.—The alloy known as Rose's *fusible metal* is composed of two parts of bismuth to one of lead and one of tin, and melts at about 200° F. A still more fusible alloy is composed of lead 3 parts, tin 2 parts, and bismuth 5 parts, which fuses at 197°. There are other alloys of lead, to be mentioned hereafter, melting at from 200° to 440°, which may be advantageously employed in forming dies to be used after zinc, where the latter, from its greater shrinkage, fails to bring the plate into accurate adaptation to the mouth.

Soft Solder is an alloy composed of lead and tin in the proportion of two parts of the former to one of the latter.

TIN.

Sn (Stannum).

Properties.—Tin is a brilliant, silver-white metal, the luster of which is not sensibly affected by exposure to the air, but is easily oxidized by heat. It has a slightly disagreeable taste, and emits, when rubbed, a peculiar odor. It is soft, inelastic, and, when bent, emits a peculiar cracking sound called the *creaking of tin.* It is inferior in tenacity and ductility, but is very malleable, and may be beaten into leaves $\frac{1}{2000}$ of an inch in thickness, ordinary *tin foil* being about $\frac{1}{1000}$ of an inch thick.

The Fusing Point of tin is about 450° F.; it boils at a white heat, and burns with a blue flame to binoxid.

The more Common Alloys of tin with other metals have already been noticed. It was at one time used as a base for artificial teeth, and more recently it has been introduced as a component of "cheoplastic" metal, a compound used for the same purpose. In its pure state, it is sometimes used for counter-dies, and occasionally for dies. When employed for the latter purpose in connection with a lead counter, the latter should not be obtained directly from the die, as the high temperature of melted lead would produce, when poured upon the tin, partial fusion of the latter and consequent adhesion of the two pieces. Tin is also used by many operators as a trial base-plate for artificial dentures, instead of wax, gutta-percha, or other more pliable materials.

ANTIMONY.

Sb (Stibium).

General Properties.—Antimony is of a silver-white color, with a tinge of blue, a lamellar texture, and a crystalline fracture. It is brittle and easily pulverized. It enters as an ingredient into the composition of type and stereotype metal, music plates, and Britannia metal. It is also a component of certain fusible alloys analogous to those already mentioned under the head of lead, and which, in the form of a die, are sometimes used on account of their slight degree of shrinkage.

The Fusing Point of antimony is 840° F., and when heated at the blowpipe it melts with great readiness, and diffuses white vapors, emitting an odor similar to garlic. The specific gravity of the purest variety is 6.715.

BISMUTH.

Bi (Bismuthum).

General Properties.—Bismuth is a white-colored metal, resembling, in some degree, antimony. It is soft, but so brittle as to be easily pulverized. Its specific gravity is 9.83, which may be increased somewhat by hammering.

The Fusing Point of bismuth is about 510° F. When the temperature of the metal is raised from 32° to 212° it expands $\frac{1}{120}$ in length.

Alloyed with Other Metals.—Bismuth has the property, in a high degree, of increasing the fusibility of the metals with which it is incorporated, and is a common ingredient of the more fusible alloys, some of which melt in boiling water. One part of bismuth with 24 of tin is malleable, but the alloy of these metals becomes brittle by the addition of more bismuth. Bismuth unites readily with antimony, and in the proportion of one part or more of the former to two of the latter, it expands in the act of cooling.

There are many other metals and alloys besides those already enumerated, but which have not been particularly described on account of their inutility in the laboratory for dental purposes. Among these may be mentioned *iron*, *brass*, *bronze*, etc., which are only employed for auxiliary purposes, and are both inconvenient and impracticable for dies by reason of their infusible nature and consequent contraction; *nickel*, on account, also, of its extreme infusibility and its tendency to render the alloy of which it is a component less fusible; *sodium*, on account of the changes produced on it by exposure to the air; *potassium*, on account of its extreme sensitiveness to the influence of low temperatures, being semi-fluid at 60° Fahr., nearly liquid at 92°, and entirely so at 120°; *arsenic*, because it volatilizes before fusing; *cadmium*, with no advantages above tin, on account of its scarcity, costliness, etc.

CHAPTER XI.

GENERAL PROPERTIES OF ALLOYS, AND THEIR TREATMENT AND BEHAVIOR IN THE PROCESS OF COMPOUNDING.

All alloys possess metallic luster, are opaque, conduct heat and electricity, and, in a greater or less degree, are ductile, malleable, elastic and sonorous. Some alloys, as brass and gong metal, are usually malleable in the cold and brittle when hot.

Metals sometimes unite in atomic ratios, forming compounds of definite or equivalent proportions of the component metals, as certain alloys of copper and zinc, gold and copper, gold and silver, mercurial alloys, etc., while, on the other hand, many are formed in all proportions, like mixtures of salt and water.

Metals differ in respect to their affinity for each other, and do not, therefore, alloy with equal facility; thus it is difficult to unite silver and iron, but the former combines readily with gold, copper, or lead.

The Ductility of an Alloy is, in general, less than that of its constituent metals, and this difference is, in some instances, remarkably prominent, as in the case of certain alloys of copper and tin, already mentioned.

An alloy is generally harder than the mean hardness of its components, a property which, when taken in connection with their increased fusibility, gives to alloys peculiar value in the formation of dies for stamping purposes. To the rule stated, amalgams, or mercurial alloys, are cited as exceptions.

The Density of an Alloy varies with the peculiar metals composing it, being generally either greater or less than the mean density of its several components.

It is impossible to predict with certainty the melting point of an alloy from that of its separate constituents, but, generally, the fusibility of the alloy is increased, sometimes in a most remarkable degree. The alloy of 5 parts of bismuth, 3 of lead, and 2 of tin is a striking example of this fact, this compound

melting at 197°, while the mean melting point of its constituents is 514°. Silver solder is also a familiar illustration of the influence of alloying on the fusibility of metals; copper, melting at 1996°, and silver at 1873°, when combined fuse at a heat much below that required to melt silver, the more fusible component of the alloy. Again, iron, which melts at a little less than 3000°, acquires almost the fusibility of gold when alloyed with the latter. Examples might be multiplied, but it will be sufficient to add that, in general, *metallic alloys melt at a lower heat than is required to fuse the most refractory or infusible component, and sometimes than the most fusible ingredient.*

The Color of an Alloy cannot, in general, be inferred from that of its component metals; thus it would be conjectured that copper would be rendered very much paler by adding to it zinc in considerable quantities, but the fallacy of such an inference is at once shown by an examination of some of the rich-looking gold-colored varieties of brass, as Prince's metal, pinchbeck, and similor, composed each of nearly equal parts of copper and zinc; and Manheim gold, compounded of 3 parts copper and 1 of zinc.

The Affinity of an Alloy for Oxygen is greater than that of the separate metals, a phenomenon that is ascribed by Ure to the increase of affinity for oxygen which results from the tendency of one of the oxids to combine with the other; by others it is attributed to galvanic action. According to Faraday, 100 parts of steel alloyed with one of platinum is dissolved with effervescence in dilute sulphuric acid too weak to act with perceptible energy on common steel. It is offered in explanation of this fact that the steel is rendered positive by the presence of platinum. A similar illustration is afforded by the action of dilute acid on commercial zinc, which is usually an alloy of zinc with other metals.

The action of air is, in general, less on alloys than on the separate metals composing them. To this, however, there are exceptions, as the alloy of 3 parts of lead and 1 of tin, which, when heated to redness, burns briskly into a red oxid.

Some points of practical interest suggest themselves in connection with the behavior and proper management of alloys in the process of compounding.

As metallic alloys can only be formed by fusion, and as the affinity of the metals composing them for oxygen is greatly increased by heat, especially those denominated base, it is important that this tendency, which is incompatible with the proportional accurateness of the compound, should be, as far as practicable, guarded against. Hence, various substances having a greater affinity for oxygen than the metals to be united, as oil or grease, rosin, powdered charcoal, etc., are generally added, coating the surface of the liquid metals, and which, by affording a protective covering, preserve, with little change, the proportions of the alloy.

The Difficulty of Securing a Homogeneous Alloy, Owing to the Difference in the Specific Gravities of the Metals Composing It.—Some difficulty is occasionally experienced in obtaining a perfectly uniform alloy, on account of the different specific gravities of the metals composing it—each metal assuming the level due to its density. This partial separation is common to gold and silver, provided they have not been adequately stirred before pouring. This result is not so likely to occur when the metals employed are in small quantities and are suddenly cooled, but when used in considerable masses and allowed to cool slowly, it is much favored by permitting the metals to fix themselves in the order of their separate densities. Hence, whenever a notable difference in the specific gravity of the metals exists, the fused mass should be briskly stirred immediately before the instant of pouring it, and should be made to solidify quickly. If uniformity be not obtained in this manner, it will be necessary to remelt, and repeat the process until the alloy is rendered sufficiently homogeneous.

The Metals that Should be Melted First.—In alloying three or more metals differing greatly in fusibility, or that have but little affinity for each other, it is better to first unite those which most readily combine, and afterward, these with the remaining metal or metals. If, for example, it is desired to unite a small quantity of lead with brass or bronze, some difficulty would be experienced in forming the alloy by direct incorporation of the metals, but union could be readily effected by first melting the lead with zinc or tin, and then adding the melted copper.

PART SECOND.

ARTIFICIAL DENTURES.

Before considering particularly the distinct and special methods employed in the construction of artificial dentures, such preliminary processes as are common in some degree to all, will, for the sake of convenient arrangement, and the avoidance of unnecessary repetition hereafter, be first considered. These processes relate: 1. To the treatment of the mouth preparatory to the insertion of artificial teeth. 2. The manner of obtaining impressions of the mouth. 3. The manner of procuring and forming plaster models of the mouth. 4. Metallic dies and counter-dies.

CHAPTER I.

TREATMENT OF THE MOUTH PREPARATORY TO THE INSERTION OF ARTIFICIAL DENTURES.

It rarely occurs that all the structures of the mouth are in such condition as will render it proper to insert an artificial appliance without some preparatory treatment. This important requirement cannot, in any material respect, be disregarded by the practitioner without endangering the utility and permanence of the substitute, and inflicting upon the patient a train of consequences alike distressing and pernicious. Every experienced dentist is familiar with the fact that an artificial substitute, resting upon diseased roots of teeth and impinging continually upon gums already irritated and inflamed, soon becomes a source not only of annoyance and discomfort to the patient, but is rendered, in a great degree, inefficient in the performance of some of its more important offices. There is, besides, a perpetual and cumulative aggravation of the morbid conditions, and sooner or later irretrievable destruction of the remaining natural organs will be induced. These consequences cannot be wholly averted by the most skilful manipulation, but they may be greatly magnified by a defective execution of the work, or by a faulty adaptation of the appliance to the parts in the mouth.

Patients not infrequently attempt, by every artifice or pretext that caprice or timidity may suggest, to persuade the operator to violate his own clear convictions of duty, but, unless under circumstances of peculiar exigency, he should be careful to guard himself against the imputation of incompetency or bad faith by being peremptory and unyielding in his demands upon the patient to submit to the necessities and just requirements of the case, and no ordinary circumstance should influence him in opposition to his better informed judgment.

The conditions usually met with, to which it will be necessary to direct attention in the treatment of the mouth, are: 1. The

presence of useless and diseased remains of teeth. 2. Accumulations of tartar. 3. Diseased states of the gums and mucous membrane. 4. Caries.

Useless and Diseased Remains of Teeth.—It may be stated, as an absolute rule of practice, that all teeth, or remains of teeth, affected by incurable forms of disease, should be removed before inserting either partial or entire dentures. This recommendation must, however, be construed in the light of the curative resources of dental surgery and therapeutics. Many diseased conditions associated with the teeth that have heretofore been generally regarded as incurable, have, in the use of more radical and efficient remedial measures, proven amenable to such treatment as assures their retention for many years in a condition fitting them for important uses. A new impulse has of late been given to such conservative treatment of these organs with the view, chiefly, of utilizing them more generally for purposes of support in setting artificial crowns, and in the method of replacement known as "bridge-work."

The marked success which of late years has attended the treatment of diseased roots, and the increasing importance attached to them for the purposes mentioned, as well also as the essential office they perform in preserving the structural integrity of the associated alveoli, and in maintaining the normal circulation and nutrition of the parts, would seem to justify the conclusion that their extraction is plainly contra-indicated, save in rare and exceptional cases of intractable disease, in which case there is no question concerning the propriety or necessity of their removal. Their presence in connection with the substitute must, sooner or later, become not only a source of annoyance and distress to the patient, but will, in all probability, lead ultimately to consequences of a still graver nature. Inflammation and suppuration will be likely to be induced, or, if already present, will be aggravated by the mobility and unaccustomed pressure of the substitute in the process of mastication, thus contaminating and vitiating the oral secretions, which act, by reason thereof, with increasing energy upon oxidizable materials present in the mouth, as well as upon the remaining natural teeth, while the contiguous parts, through their immediate connection or

sympathetic relations with the structures of the mouth, respond to the local disturbances, and the case, in time, becomes complicated with those various distressing maladies about the head and face so commonly associated with diseased conditions of the oral cavity. At last, the patient, no longer able to endure the offensiveness and distress arising from the presence of the substitute in the mouth, or to properly masticate his food, is compelled to have the offending organs removed. The absorption of the gums and processes which follows this operation, and the corresponding changes which occur therefrom in the form of the alveolar ridge, make it imperative either to reconstruct the piece or to supply the patient with an entirely new substitute; whereas, if due regard had been given to the proper preparation of the mouth in the first instance, the patient might be spared such inflictions, and the operator the discredit which almost invariably attaches to the neglect of the measures recommended.

Removal of Salivary Calculus or Tartar.—The deposits of tartar which so frequently collect at the necks of the teeth and under the free margins of the gum are a prolific source of evil, inducing ultimate destruction of the investing membranes and contiguous alveoli, and as this deposit is continuous and progressive, following closely the wasting or destruction of the implicated tissue, teeth originally firm become in time not only unfitted for the proper performance of the functions required of them, but a source of diseased action in surrounding structures. Hence it becomes absolutely necessary, as it relates to the general health of the mouth, to thoroughly remove, with suitable instruments, all traces of this concretion from the teeth. In some complications characterized by suppurating processes and necrosed alveoli, as in so-called "Rigg's disease," or pyorrhea alveolaris, the treatment must be more thorough and radical.

Diseased Conditions of the Mucous Membrane and Gums.—It will seldom be necessary to institute treatment for the reduction of inflammation and suppuration of the soft tissues of the mouth after removal of diseased roots and tartar, inasmuch as these conditions, being generally provoked by and associated with the latter, will spontaneously subside with the removal of the exciting causes. If, however, this does not occur within

a reasonable time, relief may generally be obtained with the use, as a mouth-wash, of any of the remedies ordinarily employed, as dilute tincture of arnica, myrrh or calendula, phenol sodique, etc. As a means of allaying soreness or tenderness of the gums after extraction, the writer has had gratifying success in the use of Pond's extract of hamamelis. If there are morbid conditions of the soft tissues or osseous structures of the mouth, not immediately arising from the presence of diseased roots and tartar, they should be treated in accordance with the particular pathological conditions present.

Caries or Decay of the Remaining Teeth.—In order that all the teeth which it is deemed advisable to retain in the mouth may be permanently preserved, it will be necessary to fill, or otherwise treat, such as may be affected by caries. This operation will be attended with more satisfactory results, and be accompanied with less pain to the patient and diminished risk of failure, when performed after the removal of the roots of teeth and tartar, and the restoration of diseased conditions of the mouth to health, as, in this case, there will be less irritability of the general system and reduced sensitiveness of the teeth operated on.

Surgical Treatment of the Mouth after the Extraction of Teeth.—In the operation of extracting preparatory to the insertion of artificial dentures, especially in cases accompanied by unavoidable fracture of the processes, it sometimes happens that loose and pendulous portions of gum remain, giving temporary annoyance to the patient. Any considerable excess of such tissue may be, in part at least, clipped off, while sharp and protruding portions of processes at other points should be removed, for, if allowed to remain, the gum closing over them will, in a short time, become irritated and inflamed, and exceedingly painful to the slightest pressure. If, in the course of a few weeks, prominences still remain, over which the mucous membrane is stretched and irritated or inflamed, as is more frequently the case around the sockets of the cuspidati, the membrane should be divided over such points with a lancet, and the sharp points of bone underneath broken down with suitable cutting instruments. This condition, however, can usually be obviated,

in a measure, by firmly pressing the process together immediately after extraction.

Time Necessary to Elapse after the Extraction of Teeth before Inserting Artificial Dentures.—The time that should elapse after extracting the natural teeth, before replacing them with artificial substitutes, will depend upon various circumstances. If the appliance is only intended to meet the wants of the individual until all the changes effected by absorption of the gums and processes are fully completed, it may be inserted in from one to three weeks, depending somewhat upon the number of teeth extracted,the extent of the injuries unavoidably inflicted upon the parts, and the virulence of the diseased action present in the structures of the mouth at the time of the operation. If there are no unusual complications, and the space or spaces to be supplied are such as are made by the loss of only one or two teeth at intervals, the parts quickly assume their normal condition, and the piece to be temporarily worn may be applied within a few days. If, however, a greater number or all of the teeth have been removed, more or less inflammation and tenderness will be present for from ten days to two or three weeks, rendering the wearing of an artificial piece uncomfortable to the patient, and in some degree mischievous, by aggravating the morbid conditions already existing. Another objection to the too early introduction of artificial substitutes into the mouth arises from the fact that the changes which occur in the ridge are much more rapid within the first few weeks after the extraction of the teeth than at any subsequent period, so that the plate, if inserted immediately or within a few days after such an operation, will soon lose its bearing upon the ridge and become inefficient for masticating purposes, or may even fail to be retained in the mouth without much annoyance to the patient. From two to eight or more weeks, should therefore, elapse before inserting the substitute. In the meantime, the patient should be seen frequently, and such medical or surgical treatment adopted from time to time as the case may demand.

The time occupied in the *completion* of those changes which occur in the alveolar border after the extraction of all or any considerable number of the teeth cannot be definitely stated, but

will range from five to eighteen months or more, according to the amount of superfluous structures to be removed, the density of the osseous tissues, and the functional activity of the absorbents. In all cases, ample time should be permitted to elapse in order that no appreciable change in the form of the parts may take place after the appliance has been permanently adjusted. It should be remembered, however, that there is no period of time when the changes in the maxillary bones which follow the extraction of the natural teeth may be said to be absolutely completed. It is well known that, in exceptional cases, renewed absorption may occur long after the time when it is supposed to be completed, extending in some cases quite beyond the ordinary limits. This is ascribed by many to misfitting plates, or to some particular quality of the material used as a base, notably vulcanized rubber. While there may be some plausibility in this view, it can hardly be accepted as final or conclusive. That the unusual destruction or wasting away of involved tissue is induced by some abnormal action of the absorbent or nutritive processes is without question, but whether this is induced by local or systemic causes remains in doubt.

CHAPTER II.

MATERIALS, APPLIANCES, AND METHODS EMPLOYED IN OBTAINING IMPRESSIONS OF THE MOUTH.

In the process of constructing a dental substitute, it is of the first importance that as accurate an impression as possible should be obtained of all those parts of the mouth with which the appliance is any way connected. *If this important preliminary step is in any essential respect imperfectly performed, the ultimate utility of the artificial fixture will either be greatly impaired or wholly destroyed*, notwithstanding all the subsequent manipulations may be most carefully and skilfully performed. The operator, therefore, should not only avail himself of every appliance and facility that will enable him to attain the most perfect results, but should have an exact and intelligent acquaintance with the nature, properties, and adaptability of the impression materials used.

The substances usually employed for this purpose are: beeswax, modeling composition, and plaster-of-Paris.

Some diversity of opinion exists as to the relative value of these several impression materials, and the choice of any one of the class is generally determined by individual notions of the indications to be fulfilled in any given case, and the supposed special adaptability of the material to the fulfilment of such indications.

In the case of entire dentures, where there is a near approach to uniformity of hardness or softness, and consequent uniformity of resistance, in the tissues of the mouth, plaster, of the proper consistency, unquestionably takes precedence of all other materials for the purpose, and the almost universal preference given to it in such cases is a virtual confession of its superior fitness. Its capability, beyond that of all the other substances mentioned, of securing the most perfect impression of the several parts in their undisturbed relation to each other is unquestioned, and it may be affirmed with positiveness that, except, possibly, in the case

of plastic bases, where there is no compensation for the slight expansion of the plaster, if all the surfaces on which the substitute rests were equally pliant or equally resistant to forces applied to them, no other material would be required. But, strictly speaking, this condition of uniformity never prevails, and in many cases there is a marked departure from it. The most common and troublesome complication of this kind occurs where there is a more or less pliable or yielding condition of the alveolar ridge associated with a comparatively hard and resistant surface along the median line of the floor of the palate, being more pronounced near the soft palate. In such cases, this inequality of softness and hardness, if considerable, prevents a properly balanced contact and pressure of a substitute constructed from an impression of the parts in a state of repose. Thus, for example, in the case of a perfectly fitting denture secured in the manner just stated, if the ridge along the mesial line of the palatal vault is more than usually hard and prominent, and the lateral portion of the arch and alveolar ridge relatively soft and yielding, the substitute, meeting with a fixed point of resistance at the floor of the palate, will prevent the lateral walls and ridge from being sufficiently compressed on the application of retaining forces, whether atmospheric, adhesive, or capillary, or all combined. Hence, when forcible pressure is made on one side over the ridge, as in mastication, the substitute, impinging or riding upon the central resistant surface of the arch, as upon a pivotal point, will be detached and thrown off from the opposite side. If the same yielding condition of the anterior portion of the ridge prevails, the application, when forces are applied to the front teeth, will be dislodged posteriorly.

The proposed remedy for the instability of the substitute, resulting from the conditions mentioned, consists in so constructing the dental appliance that, when applied to the mouth and subjected to the action of the retaining forces, a degree of resistance in those parts where the soft tissues are in excess will, through compression of the tissues, be secured, equal, or nearly so, to that presented by the central portion of the arch ; in other words, by establishing an equilibrium of pressure or resistance in all the parts on which the plate rests.

It is generally believed that certain forms of impression material, through the pressure they exert, are capable of contributing materially to this result. This is predicated on the assumption that the pressure they exert is sufficient to compress or displace the tissues in question. It may be well to inquire if the compressing power of these substances, in the cases under consideration, has not been overrated. If by the term compression, as used in this connection, is meant condensation or diminished bulk of tissue, certainly no such result could be obtained by any force capable of being applied within the mouth, however hard and resistant the material used. Any change in the normal configuration of the arch and ridges possible in the use of such substances must, therefore, result, *not in condensation*, *but in displacement of tissue*. It can be readily understood how this displacement may occur along the summit line of the ridge in cases characterized by considerable excess of gum material lying in loose and gristly folds, chiefly in front of the bicuspids, and associated generally with the long use of partial dentures. In applying pressure in such cases, the effect would be to force these mobile structures out of their customary relations to the ridge and arch. How far such a procedure is in accordance with the principles of correct practice must be submitted to individual judgment. That any change in the mere relative position of such loose structures to the ridge would contribute in any appreciable manner to the stability of the substitute is not very apparent.

Within the limits of the maxillary arch or palatal vault, the fossæ or depressions lying on either side of the central line are filled more or less completely with a mass of comparatively soft but elastic areolar, cellular, or connective tissue, which, in its unchanged condition, is thought to practically interfere, in many cases, with a properly balanced contact or bearing of the substitute. A partial remedy, at least, it is claimed by many, may be found in the use of some impression material of sufficient firmness to compress or displace such tissues sufficiently to afford points of resistance to the substitute equal, or nearly so, to that offered by the median line of the arch. The displacement here, if any, would be in the direction of the least resistance, or toward the

velum or soft palate, all portions of the arch anterior to the latter, except in the case of an air chamber, offering effectual resistance to displacement in any other direction. When the nature and relations of these associated soft structures of the mouth are considered, it is highly improbable, and we think impossible, that any appreciable change of contour within the arch could take place on the application of any force applied in the use of either wax or modeling composition. If these conclusions should be justified by experimental tests, as we believe they would be, it would be practically unimportant, except where the tissues of the ridge are characterized by unusual mobility, what material was used, provided a perfect impression could be obtained with it. The paramount merits of plaster, as a substance capable beyond question of fulfilling perfectly this requirement, would therefore recommend it, in preference to any other material; and we might add, too, that the more difficulties there are presented in securing an accurate impression, the more reason there is for using plaster-of-Paris as the impression material.

One possible result of the use of any of the impression materials named, exclusive of plaster, both in full and partial cases, must always render their employment of doubtful expediency whenever plaster can be successfully manipulated for the same purpose, namely, their great liability to distortion on the application of forces necessary to detach them from the mouth, and the impossibility of detecting any change of form until the error, too late for correction, is revealed in a faulty adaptation of the finished piece to the mouth. It must not, however, be understood from this that it is impossible to secure a practically accurate impression of the parts in the use of these materials. The purpose is, rather, to impress the importance and absolute necessity of extraordinary care in their manipulation in order to secure satisfactory results. The relative liability of the several substances named to such disturbance of form, and the precautions necessary to avoid such an unfortunate and generally fatal accident, will be more particularly noticed when we come to treat of them individually as impression materials. This will be done in the order before named.

Beeswax.—There are two varieties of this substance in

common use, the *yellow* and *white* wax. The yellow variety is esteemed preferable to the white on account of its superior toughness; the latter being, to some extent, disintegrated, or rendered less tenacious, in the process of bleaching, but is frequently used and is preferred by many on account of its color. The more desirable properties of the yellow wax are often impaired by the admixture with it of tallow, with which it is, for mercenary purposes, frequently contaminated. The presence of tallow may be detected by its characteristic odor, and by the whitish or pale yellow color it imparts to the wax, which in its pure state is of a deep, bright straw color.

Wax used for impressions should always be kept in convenient form for immediate use, and may be prepared either by warming it until sufficiently soft and then rolling or pressing it into thin sheets; or, having melted it in a properly formed vessel, immerse in it a strip of thin board, previously moistened, and withdraw quickly; this is repeated as the successive layers cool, until a coating of sufficient thickness is obtained. The latter is a convenient method of obtaining sheets of wax of a uniform thickness, a form frequently required for various purposes in the dental laboratory.

The following directions in the use of wax will apply also to its combinations with paraffine and gutta percha, and also to modeling compositions.

Manner of Obtaining an Impression of the Mouth in Wax for Partial Upper Dentures.—Until within the past few years, wax has been used almost exclusively for the purpose of obtaining an impression of the mouth in those cases where any number of the natural teeth remain in either or both jaws; for this purpose it is ordinarily more convenient and manageable than plaster, and, if carefully manipulated, will secure in many cases a sufficiently accurate impression of the parts.

Before preparing the wax, a suitable impression cup or tray should be selected, conforming as nearly as possible in size and shape to the general form of the arch and ridge. The proper size should always be determined by trial of the empty cup in the mouth before taking the impression.

Impression cups are made from a variety of substances, as

sheet-tin, porcelain, vulcanized rubber, and Britannia metal, and sometimes, in order to meet the requirements of special or exceptional cases, either brass, copper, block-tin, or gutta-percha may be used.

Cups constructed of sheet-tin, which any tinner can readily make to order, were formerly very generally used for partial cases, and if proper care is taken not to inflict injury to the lips and soft parts with the thin, sharp edges when introducing and pressing the cup to its place in the mouth, they may be used with satisfaction.

Porcelain cups are adapted to the use of the several impression materials named, except plaster, the latter being quite liable to part from their glazed surfaces on the application of the necessary force to detach the impression, leaving the plaster in the mouth. Aside from their purity and attractive appearance, they possess no advantages that would make them preferable to Britannia cups, while they are objectionable because of their liability to injury, and entire incapability of being changed in form to meet special reqiurements. When used in connection with wax, they should be slightly heated before the former is introduced.

Hard rubber trays, of any desired form, may be readily made from plaster models by any one accustomed to rubber work, and are chiefly adapted to the use of plaster, as they are not readily cleansed if other plastic substances are employed. Their form may be materially changed by immersing them for a few moments in boiling water.

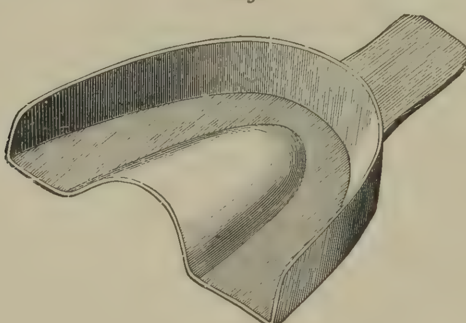
Britannia metal, however, meets most fully all the requirements of an impression cup, and is well adapted to the use of any of the impression materials commonly employed. The great variety in form and size found at dental depots will amply meet all the requirements of ordinary cases. For unusual or abnormal conditions requiring exceptional forms of trays, the operator can construct for himself, from these, such appliances as will best serve his purpose in the individual case.

The Form of Cup to Use.—Whatever cup is selected in securing an impression in wax for a partial upper case, it should be large enough to embrace the alveolar ridge, leaving a space of nearly a fourth of an inch between the rim and the external wall

of the alveolar ridge. In partial upper cases requiring an impression, it may be, of only a limited portion of the arch, as where clasps are used, or of the entire hard palate, the form of cup illustrated in Fig. 58 should be employed.

A cup designed for similar cases by Dr. Wardle, exhibited in Fig. 59, is particularly adapted to high arches, being provided with a movable palate plate, by which the central portion of the impression material is effectually forced into the highest portions of the palatal arch, and laterally against the sides and necks of the remaining teeth. The same result can be accomplished, however, by using the ordinary impression cup, and building up the rear and center of the palatine portion with softened beeswax, before introducing the plaster.

FIG. 58.



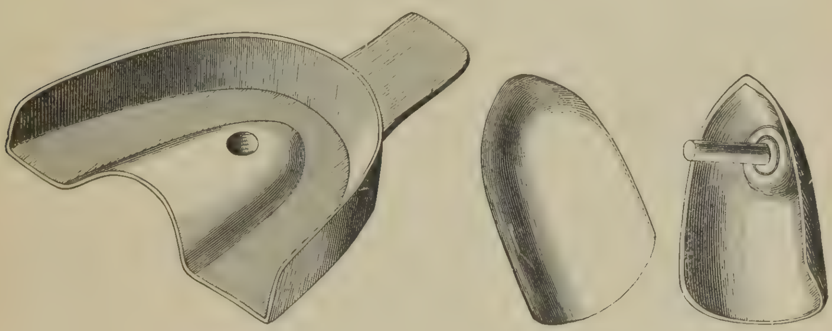
Having selected a cup of the proper form and size, the wax should be warmed over a spirit flame until it acquires about the consistency of freshly-made putty. Wax is sometimes softened by immersing it in hot water, but the dry heat is preferable, as the former seems to impair, to some extent, its toughness and continuity.

The Position of the Operator.—In taking the impression the operator should place himself behind and to the right of the patient, and should be sufficiently raised above the latter to enable him to manipulate with the greatest ease and certainty, and at the same time to command as full and unobstructed a view of the interior of the mouth as possible.

Manner of Introducing the Cup, etc.—The cup, with the

wax arranged should then be introduced into the mouth without unnecessary delay. To do this properly, and without subjecting the patient to annoyance, will occasionally require some care and expertness, on account of the disproportionate size of the cup and orifice of the mouth. An ample and expanded jaw, for example, is frequently associated with a small mouth, and if in addition to this the sphincter muscle of the mouth happens to be rigid and unyielding, the introduction of a cup of sufficient size may be attended with some difficulty and embarrassment. This impediment, however, may be readily overcome in most cases by presenting the cup obliquely to the mouth, one side resting against, and pressing outward, the corner of the mouth,

FIG. 59.



while—as the opposite corner is extended with the first and second fingers of the left hand—the cup is passed in with a rotary movement.

When the cup is within the mouth it should be carefully adjusted over the ridge before pressing it up, so that no portion of the rim may cut into the soft tissues of the mouth, an accident liable to happen without care, and which will make it necessary, in most cases, to withdraw the cup before the impression is complete. The proper position of the cup in the mouth secured, it should be held firmly with the thumb resting on the handle above, and two or more of the fingers on the under surface, when it is slowly but steadily and forcibly pressed against the parts above until the ridge is completely imbedded, and the wax

carried closely against the roof of the mouth. The cup should then be held stationary with two fingers from each hand; applying equal pressure upon both sides, while with the thumbs the wax around the margins of the cup should be pressed closely into all the depressions occurring on the outside of the ridge between the remaining teeth, or wherever irregularities may present themselves on the external border of the jaw.

After the wax has remained in the mouth long enough to become in some degree hardened, it should be carefully detached by gentle traction upon the cup, and removed from the mouth in the same manner in which it was introduced, care being taken not to displace the wax or otherwise mar the impression. The force with which the wax impression will adhere to the mucous surfaces on the complete exclusion of air is oftentimes very considerable, and will require a corresponding tractive force to dislodge it. In applying this force, it should be borne in mind that, in the very plastic condition in which the wax is applied to the mouth, *it is not only very soft and yielding, but, being wholly inelastic, is incapable of recovering its form when temporarily disturbed*, and that, consequently, any distortion of the impression occurring from the force applied in removing it from the mouth will be permanent and possibly fatal. It should, therefore, as has already been stated, be allowed to remain in the mouth long enough to become somewhat hardened, say from three to five minutes, and this process may be facilitated by holding against the cup a napkin saturated with cold water. The proper degree of hardness will, however, depend upon the circumstances of the case. If the remaining teeth present to each other parallel walls, or nearly so, permitting an easy escape of the wax from the interdental spaces, the greatest practicable degree of hardness that can be obtained is desirable. If, on the other hand, these spaces are V-shaped or dovetailed, as is very generally the case where the teeth to be replaced have been long absent, the impression should be removed while the wax is somewhat plastic, permitting a ready separation by such displacement of wax immediately around the adjoining teeth as must always occur in these cases in the use of wax. In proportion as the wax is rendered hard and unyielding will be the resistance to its escape

from these spaces, and the danger of change of form in parts of the impression more or less remote from them augmented. It is, therefore, unadvisable in such cases to produce hardness artificially by the application of ice or cold water. Under similar conditions, the same precaution should be taken against over-hardening in the use of modeling composition.

Imperfections occurring from displacement or dragging of wax on removal from the mouth, if inconsiderable, may be remedied with tolerable accuracy by subsequent carving of the plaster model, and this may be aided by a comparison of the plaster representation of the teeth with those in the mouth. If, however, the interdental under-cuts, and those associated with

FIG. 60.

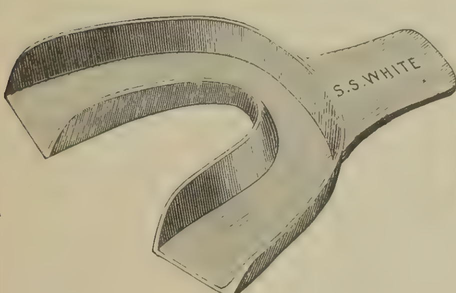
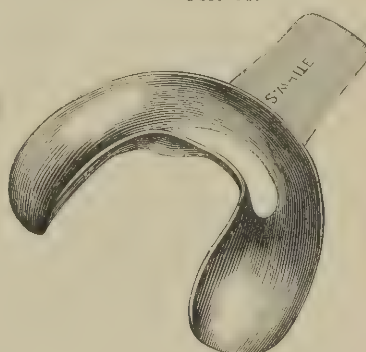


FIG. 61.



bell-crowned teeth at other points, are more pronounced, it is better to use either the modeling composition or plaster.

Inasmuch as it is necessary, in constructing partial sets of teeth, where swaged base plates are used, to be provided with two or more plaster models, and as the latter cannot well be obtained in perfect condition from a single impression, it is better that at least two of the latter should be secured in the first instance.

Manner of Obtaining an Impression of the Lower Jaw in Wax, for Partial Dentures.—If the case is one where teeth at intervals are to be supplied, the form of cup illustrated in Fig. 60 may be employed. If however, as is more generally the case, the front teeth remain, and those posterior to the cuspids or bicuspids are to be replaced, the form of cup exhibited in Fig. 61

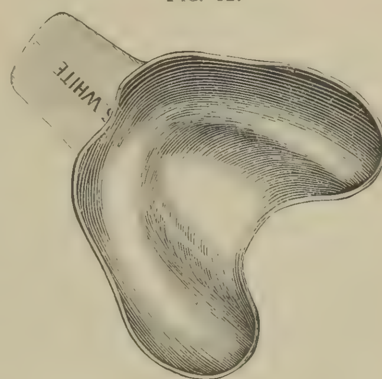
should be used, a portion being cut out from the front part of it, forming a vacuity which receives and permits an unobstructive passage of the front teeth. As the latter are often very long, it is difficult, with the ordinary form of cup, to press the wax down fairly upon the ridge behind without bringing their cutting edges prematurely in contact with the floor of the cup in front. Instead of the opening represented in the cup, however, it will be sufficient in most cases to have it formed with a depression in front of adequate depth to receive the points of the anterior teeth.

Position of Operator.—In taking an impression of the lower jaw, after having prepared and arranged the wax by softening and filling the groove of the cup flush with the margins, the operator may first take a position to the right and back of the patient and introduce the cup into the mouth in the manner heretofore described, when he may pass a little to the front of the patient, and, having adjusted the cup properly over the ridge, he should then take his place again, at the side or back of the patient, placing his fingers of each hand under each side of the patient's jaw, and the thumbs upon the top of the cup ; then make steady pressure until the ridge is wholly embedded. Before final adjustment of the wax to the ridge, however, care should be taken not to enclose any loose folds of membrane along the line of junction between the ridge and cheeks, or of loose tissue lying on the inside near the base of the tongue. To avoid the former, immediately before final pressure is made, the cheek should be distended and drawn outward with the finger, first on one side and then on the other, holding the cup, in the meanwhile, steadily in place. The loose and movable tissues on the inside will be drawn away from the ridge somewhat if the patient is directed to raise the tongue well toward the roof of the mouth. Some little additional pressure may then be made upon the cup, after which the wax should be pressed in around the margins of the cup, both externally and within, when the impression is carefully removed from the mouth, observing the precautions stated when treating of wax and other allied substances.

Manner of Obtaining an Impression of the Mouth in Wax, for Entire Upper Dentures.—The form of cup employed in

taking an impression of the upper jaw, in the absence of all the natural teeth, is seen in Fig. 62. A number of these corresponding as nearly as possible in form and size to the various modifications in the configuration and dimensions of the maxillary arch, should be kept conveniently at hand. If the teeth have been recently extracted, the wax should be prepared somewhat softer than usual, to prevent displacement of the gums, which, in their unabsorbed condition, possess more or less mobility. The cup should be filled flush with the edges, and built up in the center if the depth of the palatal vault requires it, and the wax properly trimmed; it is then introduced into the mouth and adjusted to the ridge, as already described, and pressed to the jaw with sufficient force to fully encase all the parts to which the substitute is ultimately to be applied. The wax, as the cup is pressed up, has a tendency to roll out at its edges and thus depart from the upper and outer portions of the ridge; hence care must be taken to press the wax in around the marginal portions of the cup, as has previously been directed, filling up any depressions or fossæ that may occur on the external border of the jaw. It is particularly necessary to observe this precaution whenever the ridge overhangs, as is prominently the case for the first few months after the extraction of the teeth.

Fig. 62.



If the impression is an accurate one, some difficulty is occasionally experienced in detaching it from the mouth, on account of the thorough exclusion of air from between it and the mouth, the wax being held firmly in place by adhesive force; in which event it is only necessary to admit the air between the two; and this may generally be readily effected by placing the finger against the jaw on one side and above the wax, pressing firmly toward the center of the arch and upward, forcing the

muscles and mucous membrane somewhat from the edge of the cup, and at the same time depressing the latter on the same side. A small portion of air being admitted, it will soon diffuse itself between the adhering surfaces and allow the wax to be readily detached.

To harden the wax, so as to prevent it from dragging at the points where the ridge overhangs, or to prevent any change in its shape on the application of sufficient force to detach it from the mouth, apply to the cup, for several minutes, a small napkin saturated with ice-cold water, or enclosing a piece of ice.

The writer would repeat, in this connection, his conviction that it is impracticable, in most cases, to obtain a faultless impression of the mouth in wax. There are points, not readily accessible to the fingers, where the wax departs from the external and posterior borders of the jaw, and is not, therefore, susceptible of easy correction; besides, when reached and the remedy applied, there is no certain assurance that in pressing the wax in at one point we are not displacing it at another. The same uncertainty, to a less degree, in regard to results also attaches to the use of the modeling composition. For this reason, we almost invariably use plaster, and we have sufficient reason to believe that the results are more uniformly successful.

Manner of Obtaining an Impression of the Lower Jaw in Wax, for Entire Dentures.—The method pursued in securing an impression of the lower jaw in wax for an entire denture differs in no essential respect from that described when taking an impression for lower partial pieces, the form of cup being represented in Fig. 63. When the parts are imbedded in the wax, the latter should be pressed in around the inner border of the holder, but more especially near the posterior part of the ridge on each side where the latter overhang and approximate each other, forming corresponding excavations underneath. After adjust-

Fig. 63.

ing the wax to the ridge along the border of the cup, the latter should again be pressed directly down upon the jaw before removing it, to correct any partial deformity that may have occurred during the previous manipulations.

Modeling Composition, of late years has largely superseded the use of wax for impressions. It is compounded of gum dammar, stearin, French chalk, carmin for coloring, and some perfume. The consistence of the mass depends upon the relative quantity of stearin and chalk introduced, the grades as manufactured being designated as soft, medium, and hard.

This material takes a sharper impression of the parts than wax, and its elastic property makes it more suitable where there are overhanging ridges, irregularly arranged and bell-crowned teeth, and dovetailed interdental spaces. It is prepared for use by softening it either with dry heat, or by immersing it in hot water. When sufficiently plastic, it is introduced into a cup slightly heated to render the material somewhat adhesive, and then placed in the mouth as has been directed for wax impressions.

Before removing it from the mouth, it should be cooled somewhat in order to preserve its form unchanged. Excessive hardness, however, should be avoided where portions are pressed into unusual undercut spaces, as the force necessary to detach it in such cases may produce deformity of the body of the impression more or less remote from the teeth and spaces mentioned. When removed it should be immediately dipped in cold water. The general manipulation of the compound in the mouth, both in full and partial cases, is the same as that described when wax is used, and the same care should be observed when removing the impression from the mouth.

Moldine.—This plastic compound, originated by Dr. George W. Melotte, and used by him chiefly in connection with crown and bridge work, is composed of potter's clay mixed with glycerin to the consistency of stiff putty. With the observance of certain precautions in the use of this material, the operator is enabled very quickly to secure a metallic die and counter-die immediately from the impression.

The following, in substance, is Dr. Melotte's method of using

it and of obtaining the die and counter-die. Make the tooth or teeth perfectly dry, and, filling the cup (Fig. 64) nearly full with moldine, coat it with soap-stone powder, and take the impression in the usual manner. Carefully remove the cup; trim off any overhanging material, and place the rubber ring (Fig. 65) over the cup to about one-half the depth of the ring. Melt the fusible metal and pour it as cool as it will run from the iron ladle. As soon as the metal is hard, remove it with the ring, taking care not to impair the impression, which can be used again if the die is found imperfect or is injured in use. Place the die and ring in cold water, to remain until quite cooled. While the die is wet and held over a basin of water, pour into the ring fusible metal which has been stirred until it begins to granulate, and quickly

FIG. 64.

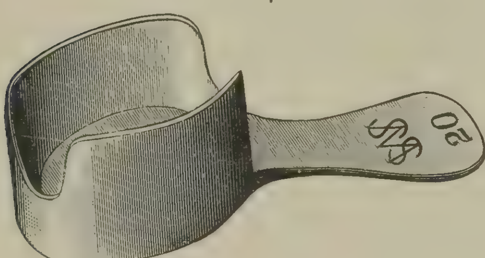
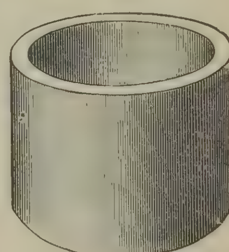


FIG. 65.



immerse all in the water. The die and counter-die should separate readily by tapping them with a hammer, but if they stick, others can be quickly made from the same impression, by the same method, using more care.

Plaster-of-Paris.—Plaster-of-Paris, or, technically, calcium sulphate, has been long employed in taking impressions of the mouth for entire dentures, and of late years it has almost entirely superseded the use of all other materials, on account of its capability of receiving a practically faultless imprint of the parts on which the substitute rests. The same quality of exactness recommends it also in partial cases where conditions exist that render an accurate impression of the parts with other materials impossible.

Derivation.—Plaster is derived from gypsum by a process of

calcination. The latter, or gypsum, is a common mineral, frequently crystallized, oftener amorphous, and oftentimes forming rock masses. Its transparent variety, called selenite, sometimes occurs in large plates, which have been used for windows. It also frequently occurs in aggregated needle-like crystals, and is then called fibrous gypsum. In its amorphous condition, when compact and translucent, it is named alabaster. More commonly it is white, opaque, and soft, and is then called snowy gypsum. The most important deposits known are those of the Paris basin at Montmartre, from which it has taken the common name of plaster-of-Paris.

Manner of Preparing.—In the preparation of plaster, as used in the arts, the gypsum rock is ground between burstones until it is reduced to a fine powder, when it is calcined by being heated in kettles or stills, the combining water being thus driven off. If, in this condition, it is again mixed with water, the latter recombines with it, the mass becoming first plastic, and then solid. Hence, it is admirably adapted to a great variety of modeling processes. In its ordinary calcined form, plaster absorbs moisture from the atmosphere, *and should, therefore, be carefully protected from dampness.* Should the latter occur, however, the uncombined moisture may be driven off by exposing the plaster to a moderate heat in a shallow pan or other suitable vessel.

In the process of hardening, after having been made plastic by the addition of water, more or less expansion of the mass, both during and for a time after solidification, takes place, varying with the kind of plaster used and the various methods employed in preparing it for molding purposes.

To Hasten the Setting of plaster use warm water for mixing, or add about ten grains of common salt (sodium chlorid) to the water before introducing the plaster, when about to take an impression. The salt also makes the plaster more brittle, which is desirable in impressions. It is better to add the salt before the plaster, as it gives it a better opportunity to become uniformly diffused. Other agents, such as chlorate of potash, potassium sulphate, and alum, have been and are used to hasten the setting of plaster; but salt is the least objectionable and answers every purpose.

Manner of Obtaining an Impression of the Mouth in Plaster, for Partial Upper and Lower Dentures.—In partial cases, whether above or below, there are, almost universally, conditions associated with the presence of the remaining natural teeth which, until more recently, have been thought to contra-indicate the use of plaster as an impression material, but experience has demonstrated that, with the adoption of certain available means and careful and skilful manipulation, there are few if any cases in which this material may not be successfully employed. Its superior capabilities of receiving a faultless imprint of the mucous surfaces recommend it for this purpose in all suitable cases.

The conditions mentioned above relate to those cases where the cervical portions of the crowns are relatively small; or where the teeth are irregularly arranged in the circle, having either an anterior, posterior, or lateral obliquity; or where there are marked depressions or fossæ on the external border of the alveolar ridge; and especially where there are well-defined dove-tailed or wedge-shaped interdental spaces. These conditions prevail in different degrees in individual cases, and the instances are exceedingly rare where some or all of them are not present. As plaster prepared for impressions, in the act of setting or hardening, becomes rigid and unyielding, and therefore practically incapable of any change of form by distortion or dragging of any portion of it on traction, the difficulty, not to say impossibility, of detaching it by the ordinary means, where these conditions prevail, will be apparent. In cases of very slight deviation from the normal position of the teeth, sufficient force, judiciously applied, will disengage the impression, provided the plaster is not allowed to set hard.

If the mal-arrangement of the teeth is considerable, or very pronounced, the separation of the plaster impression must be accomplished in some other way than by simple traction. Prof. Charles J. Essig recommends the following method of procedure:—

"An impression cup should first be selected of the proper size and shape—those with the flat floor (Fig. 58) are best for partial cases; the plaster should be mixed quite thin, adding chlorid

of soda to facilitate setting. Plaster mixed in this manner does not become so hard and unyielding as that mixed merely to saturation. Now oil the cup so that it will readily separate from the impression when hard, fill the cup as soon as the plaster thickens sufficiently, then, with a small spatula, place a layer of the soft plaster in upon the palatine surface, otherwise, by enclosing the air in the deep portion of the arch, the accuracy of the impression may be impaired. After this precaution, the cup is placed in the mouth, and gently pressed up until its floor comes in contact with the teeth. When the plaster is sufficiently hardened, remove the cup, which, from its having been oiled, is done without difficulty; with the thumb and index finger break off the outside walls; the portion covering the palatine surface is then removed by the use of a blunt steel spatula, curved at the end in the form of a hook. The pieces are then placed back into the cup, where they will be found to articulate with perfect accuracy.

"Should the first attempt be rendered futile, by the tendency to nausea or troublesome gagging on the part of the patient, camphor water, as recommended by Dr. Louis Jack, may be used as a gargle, which will, in nearly every case, prove an effectual remedy."

This device is effectual to the extent described by Prof. Essig, but it affords only a partial remedy for difficulties which present themselves in many of these cases. The most formidable obstacle to the removal of a plaster impression will be found generally in that portion of it embraced in wedge-shaped interdental spaces, and undercuts formed by truncated, cone-shaped crowns, and malpositions of the teeth; and when the outside walls of the impression alone are broken off, and remaining portions are imbedded in these undercuts, it will rarely be possible to remove the portion covering the palatal surface without further fracture and removal by sections.

The author is indebted to Prof. Wilbur F. Litch for the following description and illustration (Fig. 66) of a method of securing plaster impressions for partial cases:—

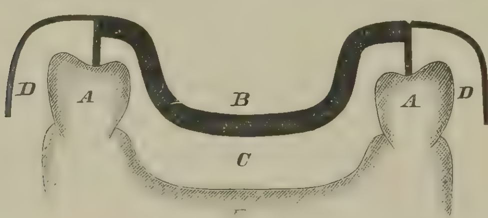
"A wax impression tray is made, and either scored or perforated, to afford anchorage for the plaster. This extends only

midway of teeth or interspace. After the plaster has hardened, the outer edge is trimmed, notched, and oiled in the mouth, and sections D D of the diagram made by carrying plaster into position by means of a spatula, the outer section being made in two pieces, joined at about the median line. The three pieces are removed separately and joined by means of the notches made in the palatine section C, into which notches the plaster of sections D D will fit. After the three sections are cemented together, they may be embedded in plaster, to more securely hold them together while the model is being poured."

Another method of securing plaster impressions in sections is the following, suggested by Dr. A. G. Bennett:—

"A wax cut-off is placed in the floor of the impression tray

FIG. 66.



A A. Teeth or interspace. B. Wax impression tray. C. Plaster impression of palatine vault and palatal half of teeth or interspace. D D. Buccal or labial half of teeth or interspace. E. Palatal vault.

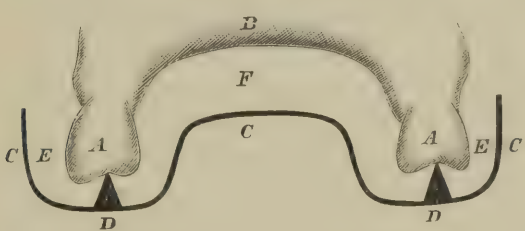
in such manner that it will touch the crowns of the molars and the cutting edges of the incisors about midway between their buccal or labial and palatine walls, as shown in Fig. 67, letters D D. After the wax cut-offs have been firmly attached to the tray by heat, the tray is oiled, filled with plaster, and placed in position in the mouth. After the plaster has hardened, the tray is withdrawn, the plaster remaining in the mouth, when the outer sections, E E, are readily broken off, and the plaster section, F, withdrawn. The several pieces are then replaced in their proper position in the tray."

Another method of procedure in the class of cases under consideration is that described by the late Dr. F. M. Dixon, of Philadelphia, which seems to provide more perfectly for the

removal of the palatal portion of the impression in cases characterized by unusual inward inclination of the teeth. The process described relates to partial upper cases :—

" First take an impression of the whole upper jaw in wax, and harden by applying ice-water. Divide this impression, with a slightly heated knife blade, into the number of sections desired for the plaster impression. From the inner surfaces of these sections, a sufficient quantity of the wax is cut away to make room for the required amount of plaster. Hard-setting plaster is then poured into one of the palatal sections, and the latter placed in its proper position in the mouth, securing an impression of the palatal surfaces of the teeth of that side, and about one-third of the palate of the same side. When the plaster has

FIG. 67.



A A. Molar teeth. B. Palatine vault. C C C. Impression tray. D D. Wax cut-offs. E E. Labial sections of plaster impressions. F. Palatal section of impression.

hardened sufficiently, the section is removed and laid to one side while an impression of the opposite side is secured in the same manner.

" The patient may now be dismissed with an appointment for another sitting. In the interim, these sections are carefully trimmed in such a manner that the lower or lingual surface shall present a bevel from margins near the mesial line of the palate to the grinding surfaces of the teeth, that the next section may be readily removed after the hardening in the mouth. When the patient returns, the prepared lateral sections, oiled on their under surfaces, are placed in the mouth and an impression of the central portion of the palate and palatal surfaces of the incisors is secured as before. The impressions of the buccal

surfaces, when needed, are taken in like manner, with the other sections in situ."

Manner of Obtaining an Impression of the Mouth in Plaster for Entire Upper Dentures.—The form of cup used in securing an impression of the upper jaw for entire sets of teeth differs in no essential respect from that recommended when wax is used for similar purposes (Fig. 62). If the external border of the alveolar ridge is very deep, or there is considerable space intervening between the heel of the cup and the floor of the palate, a rim of wax should be placed across the posterior border of the cup, to carry the plaster well up at this point, so as to secure an accurate impression, and to more effectually confine the plaster within the cup and prevent its escape into the back part of the mouth before it has fairly reached the palatal vault. If the latter is extremely deep, with a marked excavation in its central and anterior portion, or if it presents somewhat the form of a deep fissure, the plaster may fail to be carried perfectly against the floor of the palate, or the air, becoming confined within the central portion of the arch, when the plaster is pressed up, may displace the latter and form corresponding chambers in the impression. If these imperfections are but slight, they may be subsequently remedied either by filling up the cavity or cavities in the impression, or by trimming away at these points from the model. The better plan, however, where these conditions of the vault prevail, is to take up a small portion of plaster on the end of a spatula and apply it to the deeper portions of the arch just before introducing the cup. In preparing plaster for use in these cases, it should be so treated as to insure quick setting when applied to the mouth. This is generally accomplished either by adding to a very thin mixture of plaster and water a small quantity of sodium chlorid or common salt and stirring until it begins to thicken. It then adapts itself readily to the parts, hardens quickly, and is not liable, with ordinary care, to incommode the patient by running back too far upon the soft palate or into the fauces. So quickly, indeed, does it condense, that unless expeditiously introduced into the mouth, it will begin to "set" before the parts are fairly embedded. When preparing it for use, therefore, the plaster should be mixed at

the chair with the cup conveniently at hand, while the patient should be in proper position and in immediate readiness for the operation.

In view of the liability of the plaster to run back into the fauces when the cup is pressed to its place in the mouth, producing nausea and involuntary retching, and which is very liable to occur whenever the mixture is too thin or is improperly manipulated, it is recommended to instruct the patient to avoid swallowing while the plaster is in the mouth, and to breathe entirely through the nostrils, which act keeps the mouth and throat quiet, and hence less liable to irritation from the impression material and the accumulation of saliva in the mouth.

Position of Patient, etc.—The patient being seated as nearly upright in the chair as possible, with the head inclined slightly forward, the cup is filled with the plaster mixture and introduced quickly into the mouth, when it is pressed up slowly and gently (the rear or heel of the cup first, which causes most of the surplus plaster to be forced forward), until the parts are completely encased and portions of plaster are seen to protrude from all parts of the margins of the cup, otherwise the impression is liable to be imperfect, either on its outer borders or on its posterior palatal face. Immediately after introducing and pressing up the cup, the lip in front should be extended and drawn down over the cup, when gentle pressure, as the plaster is hardening, may be made upon the lip and cheeks, to force the plaster more perfectly into close contact with the outer surface of the alveolar ridge.

It is essential to perfect success in this operation that the cup, after the parts are once embedded, should be held perfectly stationary until the plaster becomes fixed, as the slightest movement when the plaster is in the act of consolidating will derange the impression and render it faulty. Again, if after the parts are embedded the operator discovers that they are not sufficiently encased, and the plaster has partially set, no further effort should be made to press the plaster up upon the parts, but the cup should be withdrawn and the operation repeated with fresh plaster.

If the operation has been successfully conducted, the plaster will adhere to the mouth, in most instances, with great tenacity,

and it will be necessary to observe some caution in removing it, for, if forcibly detached, injury may be inflicted upon the soft parts by tearing away portions of mucous membrane; or the impression may be badly fractured or otherwise impaired. In addition to the means already alluded to in connection with the method of separating wax impressions from the mouth, resort is sometimes had to the following expedient: The central portion of the cup being pierced with two or three small holes, a blunt-pointed probe is passed at these points through the plaster, before the latter has hardened perfectly, to the roof of the mouth. Into these passages the external air passes and diffuses itself between the surface of the plaster and the palate, when the impression may be readily detached. The writer, however, has succeeded best in detaching impressions in such cases by upward and interrupted traction upon the handle of the cup, which, by depressing the latter posteriorly, more readily permits the introduction of air than by either of the methods commonly employed.

Manner of Obtaining an Impression of the Mouth in Plaster, for Entire Lower Dentures.—The general form of cup used for the above purpose is shown in Fig. 63. This being filled with the plaster mixture, prepared as described in connection with full upper pieces, is inverted and quickly introduced into the mouth and pressed down upon the ridge until the latter is completely embedded, being careful at the same time to draw the lower lip away from the cup, and the cheeks outward, in order to prevent any loose tissues from folding in upon the outer borders of the ridge as the cup is pressed to place, thus seriously marring the impression.

It is thought by many operators that better results can be secured by first taking the impression in wax, enlarging the impression thus secured with suitable instruments, and using this as a tray for plaster.

CHAPTER III.

PLASTER MODELS.

After an impression of the mouth has been secured in either of the ways mentioned in the preceding chapter, the next step in the process of constructing an artificial denture is to procure from the impression a representation of the parts in plaster. The copy thus secured is called a MODEL, or cast, and if correctly obtained is a true counterpart or fac-simile of all parts of the mouth represented in the impression.

Manner of Obtaining a Plaster Model from an Impression in Wax or Modeling Compound, for Partial Dentures.— The impression should be first trimmed by cutting away superfluous portions that overhang the borders of the cup, care being taken not to mar any essential part of the impression. The surface imprinted should then be uniformly and thinly coated with soapy water or oil, applied with a camel's-hair brush. This should not be of too thick a consistency, nor applied in too large quantities, as it will collect in the more depending portions of the impression, and, failing to be displaced by the plaster, leave the model imperfect at these points, especially at the coronal extremities of the plaster teeth. The cup is now surrounded by some substance that will confine the plaster and give proper form to the body of the model. For this purpose any material that is easily shaped may be used, as a thin sheet of lead or wax, paper, strips of oil or wax cloth, etc.

Before pouring the plaster, if it is desired to strengthen any of the plaster teeth—as those adjoining the vacuities in the jaw, or such as are to be used in adjusting clasps—and thus secure them against accident in handling, adequate support may be imparted to them by placing short pieces of stiff wire vertically in the depressions made in the impression by the teeth, supporting them in an upright position by embedding one end in the wax or other material in the center of the bottom of each cavity.

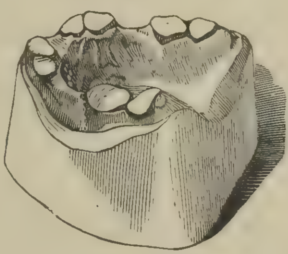
When the cup is properly inclosed, a batter of plaster, of somewhat thinner consistency than that used for impressions, is poured in upon the surface of the wax in sufficient quantity to give to the body of the model a depth of from one to three inches, according to the particular requirements of the case. The plaster should not be poured directly or hastily into the cavities formed by the teeth, but upon points contiguous to them, and from which it should be allowed to run slowly into the depressions, by tapping the bottom of the cup gently upon the table, thus expelling the contained oil or air, and filling them perfectly. When the plaster has become sufficiently hard, any portions overlapping the borders of the impression, and not essential to the form of the model, should be cut away, and the two separated by immersion in warm water until the warmth imparted to the model renders the impression sufficiently soft to allow the former to be removed without fracturing the plaster teeth.

The general form of the body of a model is shown in Fig. 69. Where a swaged base is required, the walls, as will be seen, are made as nearly vertical or parallel as will admit of the model being readily detached from the sand in the process of molding; for if made too flaring or divergent, the metallic die obtained from it will be more liable to crack or spread apart under the repeated strokes of a heavy hammer, or to rock under one-sided blows.

During the process of stamping or forcing a metallic base into adaptation to the die—which is a metallic counterpart of the model—the plate, when cut to the exact pattern of the parts to be covered by it, is frequently forced or dragged back toward the heel of the die, and is thus drawn from the teeth at the sides and in front. This displacement of the plate may be prevented by cutting away all of the plaster teeth from the model, leaving, however, enough of them remaining where they unite with the body of the model to form a shoulder to each tooth, as in Fig. 68. In this case the plate should be sufficiently ample in its dimensions to partially overlap the border, when, as it is forced into adaptation, distinct indentations will be made in it, corresponding exactly with the palatal curvatures of the teeth; the portions of the plate covering the cut ends of the teeth are then

cut away with plate forceps or other instruments. If, however, the plate is of the exact size required before stamping, one or two plaster teeth upon each side of the model may be allowed to remain, against the anterior face of which the plate is made to rest, holding it stationary.

Fig. 68.



Manner of Obtaining a Plaster Model from an Impression in Wax or Modeling Compound, for Entire Dentures.—The same general method is pursued in obtaining a plaster model from an impression of either the upper or lower jaw for entire dentures with the substances mentioned, as that employed in partial cases. The general form of these pieces is represented in Figs. 69 and 70.

If it is desired to swage a rim to the plate, forming a groove or socket into which the plate extremities of the teeth are re-

Fig. 69.

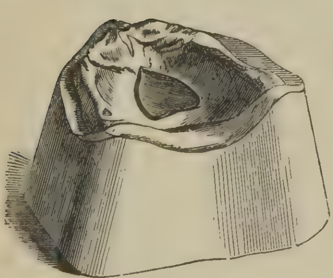
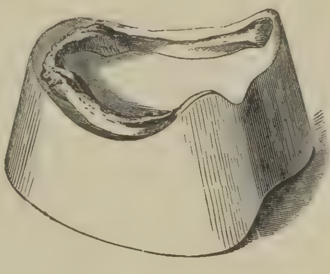


Fig. 70.



ceived, the model should be formed in the manner represented in the annexed cuts; in which it will be seen that an abrupt shoulder is formed on the external border of the model of the upper jaw (Fig. 69), but which on the lower (Fig. 70) is extended round the inner border also, as it is desirable, in the latter case, to give a rounded edge to the lingual border of the plate, and which is accomplished in part by swaging in the first instance

and afterward by turning the edge down upon the plate with pliers or by other means. The model is prepared by adjusting a strip of softened wax around the border and cutting away from its upper surface in such a way as to form a groove, the bottom of which shall be on a line with the extreme edge of the base or plate, which should be indicated upon the model with a pencil mark before applying the roll of wax.

Rimmed plates, however, are only required when single gum teeth or sectional or entire blocks are employed, or when plate teeth are mounted on a platinum base with continuous gum.

Forming the Air Chamber.—Whenever an air chamber is to be stamped in the base, the model should be prepared for the purpose before casting the metallic swages. The general form and position of the central cavity or chamber in the arch is represented in Fig. 69. The model may be prepared in either of the following ways: 1. The form of the chamber may be cut from the wax or plaster impression, in which case the plaster will be raised at a corresponding point or points upon the model, and will have exactly the same form and depth as the cavity in the impression. 2. Cover the palatal face of the model with a sheet of wax equal in thickness to the required depth of the chamber, and cut out from this, at the desired point, the form of the cavity; fill the latter with plaster, and when hard remove the wax and trim the raised portion to the proper form. 3. Cut a pattern, of the required form and depth of chamber, from sheet wax or lead; place it in proper position in the arch, and press down with the fingers or burnisher until it conforms to the contour of the palate; it is then fixed in place either by confining it with a small pin or tack driven through it into the plaster, or by interposing softened wax or other adhesive material between the pattern and model. A small brush loaded with a varnish mixture passed around the edge of the pattern will insure sufficient adhesion of the latter.

The same general method as that when central chambers are formed is pursued in the preparation of the model when it is desired to construct lateral cavities in the plate. The form and position of these on the model will be indicated by inspection of

the form of "lateral cavity" plates as exhibited in the chapter on "Entire Dentures."

There are other modifications in the form of cavity plates, some of which are obsolete; that known as "Cleveland's chamber" is still in limited use, but does not require a model differing in form from the one described in connection with full dentures with central chambers.

Manner of Obtaining a Plaster Model from an Impression in Plaster, for Partial Dentures.—The surface of the impression in plaster should be first glazed, by applying to it, with a camel's-hair brush, a uniform coating of varnish, to prevent adhesion of the model. Two kinds of varnish are in common use—a transparent and colored. The former is preferred, for the reason that it penetrates the plaster more thoroughly, giving to it a greater depth of surface hardness, while the latter, if not sufficiently fluid, forms a somewhat superficial incrustation, which is liable to peel off in handling, leaving portions of the model unprotected. Either, however, if properly prepared and applied, may be employed.

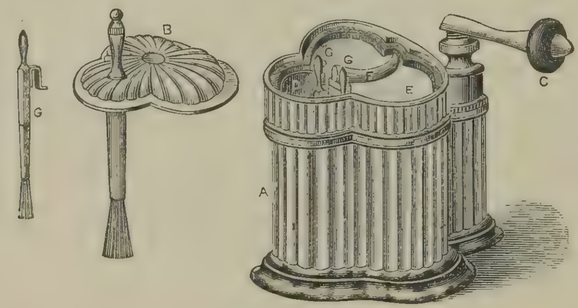
Formula No. 1. TRANSPARENT VARNISH.		*Formula No.* 2. COLORED VARNISH.	
Gum sandarach, . . .	5 oz.	Gum shellac, ...	5 oz.
Alcohol, ...	1 quart.	Alcohol, ...	1 quart.

The sandarach and shellac should first be freed from all impurities by careful picking and washing; they are then added to the alcohol and digested over a moderate heat until thoroughly dissolved. Other substances, as gum elemi, Venice turpentine, etc., have been recommended as additional ingredients, but they are not indispensable, and may be omitted without sensibly impairing the properties of the varnish.

The varnish, or separating fluid, should be kept securely bottled, to prevent evaporation of the alcohol, and keep it free from dust and other foreign substances. For this purpose the "Clover-Leaf Holder (see Fig. 71) is probably the most convenient, neat, cleanly and economical receptacle on sale for that purpose. The body is of glass with nickeled mountings and cover. It contains two compartments, the larger for the

varnish, the smaller for the brushes, of which there are three, a large one attached to the lid, and two smaller ones which depend from the partition between the compartments by means of a little hook. Across the main compartment is a scraper to remove surplus varnish from the brushes. The lid is held in place upon a rubber ring with a firm pressure, by means of a rubber wheel attached to a swinging lever. This makes the holder air-tight and prevents evaporation of the varnish. The brushes are specially made for varnish, of fine goat's hair, which is better for the purpose and more durable than camel's hair. A little alcohol placed in the brush compartment keeps the brushes pliable and is convenient for thinning the varnish when desirable.

FIG. 71.



After glazing the surface of the plaster impression with varnish, a thin and uniform coat of oil or soapy water should be applied; it is then enveloped, and the model procured in the same manner as when the other plastic materials are used.

The following method of preparing the plaster impression before it is filled in for the model is recommended by Dr. C. W. Spalding: "After the impression has become hard, coat the surface with a lather of soap and water; wash this off and immerse the model in water. This expels air and avoids liability to porosity of the surface of the model. Again coat the surface with a strong lather of soap and water, and wash off as before, when the impression is ready to receive the plaster for the model. I prefer this method to varnishing, for the reason that the varnish used is not always of uniform consistency."

In separating the model from a plaster impression, for partial cases, it will be necessary to cut the latter away in pieces, as any attempt to separate the two in the ordinary manner would inevitably break away the plaster teeth from the model. The impression should be chipped away with care, to avoid defacing the model. To provide more perfectly against this accident, it is better to coat the impression with colored varnish, as this will indicate with greater certainty the line of contact or union between the two pieces. Dr. Spalding suggests a simple and effective device for the same purpose, which consists in coloring the water used to mix the plaster for the impression with anilin red. When separated, the model should be trimmed and formed in the manner before described.

Manner of Obtaining a Plaster Model from an Impression in Plaster, for Entire Dentures.—The preparation of a plaster impression of either the upper or lower jaw, for full dentures, and the method of procuring a model therefrom, differ in no essential respect, except in the mode of separation, from the manipulations required when the impressions have been taken in plaster for partial pieces. A model can, ordinarily, where there are no considerable depressions or undercuts on the external face of the ridge, be readily separated, either by taking the model in the hand and tapping the handle of the cup, or by forcing a wedge-shaped instrument between the impression and model at the posterior border. When, however, there are considerable undercuts, such as usually prevail on either side of the median line in front, above and below, or the anterior and middle portions of the ridge are thin, prominent, and overhanging, the application of sufficient force to detach the impression in a body will inevitably fracture such portions of the ridge of the model as are engaged in the contracted spaces. In such cases, the cup being removed from the impression, the latter should be grooved as deeply as possible without marring the face of the model, in such a way that, when the instrument is forced in at suitable points, the impression will be fractured on a line with the grooves, and thus be detached in sections. One groove may be made continuously along a line corresponding with the summit of the ridge, and others extending at right angles with this

to the outer borders of the impression. When these external sections are removed separately by wedging at the extreme border of the impression, the whole central portion will be easily detached. Extreme thinness and prominence of the ridge will most generally be found in connection with the lower jaw, and will require cautious manipulation to avoid accident to the model. If any portion of the model should be defaced, it may be remedied by restoring the contour with plaster. After detaching the model in the manner mentioned, the entire body of it should be glazed and hardened by applying to it a thin and uniform coat of varnish, if it is to be used in obtaining a metallic die. This protective covering will prevent the surface from wearing, render it more pleasant to the touch, facilitate its withdrawal from the sand, and give a more perfect mold. A model may be better prepared for permanent preservation by immersing it for a short time in a solution of carbonate of soda, by which its surface is converted into carbonate of lime, and thereby rendered hard and durable; care must be taken not to introduce any of the bicarbonate of soda into the solution.

CHAPTER IV.

METALLIC DIES AND COUNTER-DIES.

A Metallic Die is a *fac-simile* or transcript of the mouth in metal, and is also a copy or likeness of the plaster model.

A Metallic Counter-die is a copy of the impression, and is a reversed image of the die and plaster model.

Manner of Obtaining a Metallic Die.—Two general methods are employed in procuring a metallic counterpart of the model; first, by *molding;* secondly, by a process termed "*dipping.*" The first only, however,—being the more practical and more generally used,—will be considered.

Materials Used in Molding.—For this purpose the best material is marble-dust, though other substances, as sand, Spanish whiting, etc., have been recommended. Marble-dust has the advantage of being always ready for use, as it absorbs sufficient moisture from the atmosphere to render it cohesive, is cleanly, and gives a smooth and uniform surface to the die. When sand is used it should be fine and even-grained, the best for the purpose being that used by brass founders. It is prepared by mixing with it sufficient water to render its particles somewhat adherent, so that when portions of it are pressed in the hand and then parted with the fingers it will break away in well-defined fragments. Excess of water should be avoided, as the vapor formed by the molten metal, when poured upon it, will displace portions of the latter and form cavities, or blisters, in the face of the die; nor should the sand used be too dry, as in that case it will crumble away in detaching the model.

Oil has been proposed as a substitute for water, in which case it is recommended to add one quart of the former to a peck of sand. It is claimed that the sand so prepared is always in immediate readiness for use.

Preparing Model Previous to Molding.—In upper cases, whether partial or full, a shallow groove should be made

along the posterior plate line, so that when the plate is swaged this edge will press firmly against the roof of the mouth. The cast should also be carved at the points where the integument of the palate is soft and yielding. In some cases the center of the palatal portion of the mouth is unusually hard and unyielding; in fact, large, bony prominences are sometimes found; these points should have a thin layer of wax placed over them, so as to relieve the pressure, otherwise the plate would rock, thus interfering with the adhesion and the wearer's comfort. The form for the vacuum-chamber should also be built up with wax or other material, when the cast will be ready to proceed with the molding.

Manner of Securing Mold.—The molding material being properly prepared, the model is placed with its face uppermost on the molding board and surrounded with a metallic ring. What is known as the Bailey Molding Flask is used by many operators. A common "wagon box," however, of which two or three sizes should be had, will answer every purpose in ordinary cases. If sand is used, it should first be well sifted, to remove the coarser particles, and then filled into the ring, packing it closely with the fingers around and over the model until even with the upper edge of the box. Some care must be observed in the management of the molding material when packing it, for, if made too compact, the vapor formed in pouring hot metal, failing to pass out readily, will be confined within the cavity and cause imperfections in the face of the die; or, if too loosely packed, the fluid metal, when poured into the mold, will, to some extent, permeate the pores of the sand, or other material, and render the face of the die rough and imperfect.

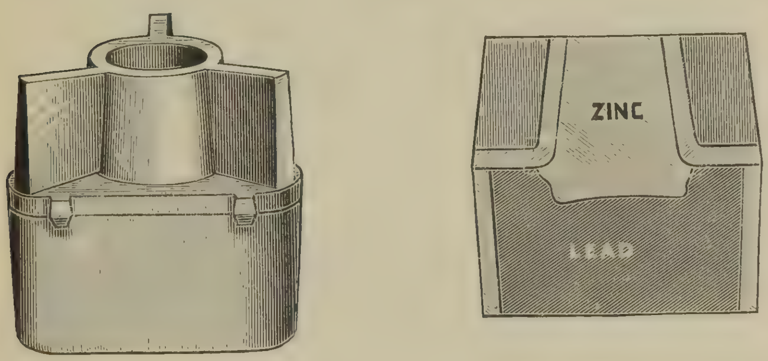
Manner of Withdrawing the Cast.—After the sand has been well packed, level off the surface with a rule, lift the flask or ring with its contents from the bench, turn it over carefully, and lay it down with the bottom of the cast up. Now run the point of a tack or the small blade of a knife into the center of the cast with a few gentle taps from the hammer. Grasp the knife or head of the tack firmly between the thumb and fingers, and with a small hammer distribute a few gentle taps over the surface of the cast. If the cast cannot then be withdrawn, continue

the process and at the same time distribute a few gentle blows over the edge of the molding ring, when it will usually be found that the cast can be readily lifted out. All these manipulations must be very gentle or the cast may be tilted or rocked in the sand, and thus make a false impression.

Another method of removing the cast from the sand, usually given in the text-books, is to re-invert the ring and contents, hold it above the table, and dislodge the cast by tapping it gently underneath. I should, however, in nearly all cases reject a mold from which the cast had fallen out by its own weight.

The Lewis Molding Flask.—This new form of flask, introduced by the Buffalo Dental Manufacturing Co., is an improve-

FIG. 72.



ment upon the Bailey Flask for molding dies; the top part, which forms the zinc die, being entirely new in shape and purpose. By the use of this flask, the metal in the die is concentrated above it, so that it has no outside bearing upon the counter-die; thus overcoming what is to many dentists a serious objection to dies produced with the ordinary flasks or rings, viz., the bearing of the die upon the counter, outside of the model, preventing the driving of the former into the latter as it yields in swaging, unless the method suggested by Dr. Broomell on page 178 is employed. In dies produced by the Lewis Flask the bearing of the die upon the counter is limited to the model, and a more perfect adaptation can be secured between it and

the plate. With this flask a thin model can be used, at the same time all the advantages of the old-fashioned, thick or built-up model secured.

When this form of flask is employed, the procedure is as follows: A thin plaster cast should be trimmed to give proper draft at the edges, varnish and dry thoroughly. Before proceeding to mold, dust it with a little finely-powdered charcoal, shaking off all that does not adhere. Invert the top or winged section of the flask, fill its conical cavity with sand, leaving it a little high, and press the back of the model firmly upon it, to secure a solid foundation and prevent rocking. Place the ring in position, and sift the sand into it, ramming it down carefully. Strike off the surface of the sand level with the top of the ring. Reverse the flask, holding the sections together securely, then remove the winged section and draw the model. Fill the depression in the sand with the molten metal, then place the upper section of the flask in position—the sand having previously been knocked out of it—and complete the pouring of the metal. When the die has cooled, smoke its exposed surface, and replace it in the winged part of the flask; knock the sand out of the ring, place it in position, and fill with the counter-die metal.

The Hawes Flask.—It not infrequently happens that the ridge on the plaster model of the upper jaw overhangs, forming corresponding depressions above, the excavations occurring more commonly in front and on each side of the mesial line. Whenever this form of the model exists, it will be impracticable to obtain a correct mold with either of the methods just described, since the sand, becoming impacted in these excavations, will be broken away and remain with the model when the latter is dislodged.

The difficulty mentioned, however, may be readily overcome in all cases by employing the sectional molding flask invented by Dr. G. W. Hawes, the several parts of which are represented in the accompanying cuts.

Fig. 73 represents the lower ring, composed of three movable pieces, with flange extensions that project in toward the center. When used, this portion of the flask is closed and the sections

kept in place by pins passing through the joints. Inside of this ring the model is placed face upward, the ridge extending a little above the upper plane of the ring. Sand, well sifted, is then packed in around the model on a level with the most projecting points on the outside of the ridge, as indicated by the dotted line in Fig. 75. The surface of the sand should be trimmed smoothly, and should be cut squarely and at right angles with the ridge to prevent the sand from breaking away when the model is withdrawn. Very finely pulverized charcoal, contained in a loose muslin bag, is now sifted over the exposed surface of

FIG. 73.

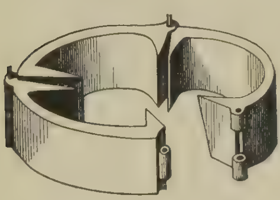


FIG. 74.

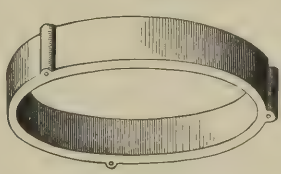
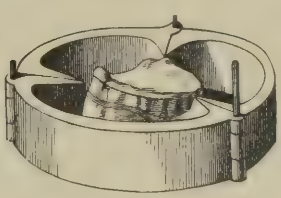


FIG. 75.



the sand to prevent the next portion contained in the upper ring from adhering. The plain ring (Fig. 74) is then placed over the one containing the model, and is filled with sand well packed over the face of the die. The upper ring is now carefully lifted from the lower one on a line with the pins, thus separating the two portions of sand, and again exposing the uncovered face of the model. One of the pins should then be drawn from the lower ring, the sections of the latter carefully unfolded, and the model withdrawn; when the ring may be again closed and confined by replacing the pin. The upper ring is then readjusted in its proper relation to the lower one, the flask inverted, when

the mold, if the process has been accurately conducted, will be found perfect.

In the absence of the " Hawes " flask, the same results may be attained by employing the following simple method, recommended by Dr. Berhard, and subsequently described as follows: " The plaster model being prepared in the usual manner for molding, varnish the front (or the whole) with a thin solution of shellac. When dry, apply a mixture of plaster of proper consistency to the front of the model, from the bottom up to the edge of the alveolar line, spreading it on both sides so as to entirely fill up the depression around, making the lower half an inch thick, and sloping off toward the alveolar ridge. When this has hardened, separate it from the model, and draw the top of it over sand-paper to obtain a flat edge, and let it dry. Readjust this front piece to the model; procure a mold in sand or other material, in the usual way; place the extra piece back in its proper position in the mold, and proceed to cast for the die."

In obtaining a mold from the model of a lower jaw, but little difficulty will ordinarily be experienced in obtaining it perfect in the manner first described. The depressions at the posterior and inner border of the ridge are the points most liable to drag or displace the sand, and when the latter occurs, the surplus metal in the die at such points must be cut away with suitable instruments; or the cavities in the model may be so filled out with wax before molding as to permit the ready separation of the model without displacing the sand, in which case, also, it will be necessary, afterward, to trim the redundant metal from the die.

Preparing Cast for Mold, for Partial Dentures.—A die is more readily and accurately obtained from a model for partial dentures by cutting away the plaster teeth, as before described. The displacement of sand where the ridge overhangs will, as a general thing, be unimportant in these cases, as the base seldom more than partially overlaps the border.

When whiting or marble-dust is used in molding, it is unnecessary to mix water with them, as the moisture which they absorb from the atmosphere will give to them the proper consistency.

Preparing and Pouring Metal for Dies.—Having obtained a mold in either of the ways mentioned, the metal designed for the die should be melted and poured carefully in upon the more prominent portions on the face of the former. If the metal is raised much above its fusing point, or the sand is quite damp, the former should be poured very slowly into the mold. It is better, however, that the sand should be partially dried before pouring the metal, and the die cast, on the instant of the metal becoming sufficiently fluid. An observance of these precautions will protect the sand from the over-action of heat, prevent ebullition of the fused metal from the too rapid decomposition of the water in the sand, will give a smoother face to the die, and secure the metal or metals from undue waste by oxidation. The opinion is entertained by some, that greater shrinkage of the die occurs when the metallic substance of which it is composed is poured at a temperature much above its fusing point; the fallacy of this is made obvious by a moment's reflection, as a simple example will show that any change affecting the face of the die, as a consequence of contraction, can only occur in the metal between its point of solidification or liquefaction—for they are identical—and its working temperature. Zinc, for example, melts at 773°. Now if its temperature be raised to 1200°, it will remain fluid until it reaches 773°, and in passing through the intermediate degrees of heat, it will, in obedience to gravity, adapt itself perfectly to all parts of the more depending portions of the mold; and this perfect continuity of the two surfaces will remain unaffected by the contraction of the metal until the latter commences to "set," or solidify, after which, and not until then, the zinc begins to part from the face of the mold by contracting upon itself between 773° and the mean temperature of the air. So far as any change, by contraction, in the face of the die is concerned, therefore, it is obviously immaterial whether the zinc be poured on the instant of melting or at 1200°; the result will be the same in either case.

The author is indebted to Dr. B. W. Franklin for the following method of securing metallic dies and counters by a process which greatly facilitates the operation and insures accurate and satisfactory results: "I take all impressions, full and partial, in

plaster. A small hole, less than $\frac{1}{16}$ of an inch, is drilled through the highest point of the palatal surface of the impression, through cup and all; into this place two or three broom splints, cutting them off even with the surface of the plaster, to allow any vapors to pass off. I sometimes smoke the surface of the impression. Around the impression place sufficient putty to form a ring the size and height required for the die. Into this pour, at as low heat as is consistent with the mobility required for sharp castings, the bismuth alloy known as Sir Isaac Newton metal, or, which is better in some respects, 8 parts bismuth and 4 parts each of tin and lead—the latter composition being a little harder. If a little judgment is exercised in pouring either of the above alloys, a perfect die will be secured from moist plaster impressions without any drying. As the bismuth is expansive and the alloy is hard and somewhat brittle, I run only a thin casting, not more than half an inch in thickness, over the highest portion of the impression. I have cast-iron or brass heads made, 3¼ inches in length, 3 inches in diameter at the large end, and 2 inches at the other; the large end is flat, and well coated with common tinman's solder. This head is heated until the solder begins to soften; it is then placed in a pan or other convenient vessel, and the die, face side up, is placed upon the tinned surface. When the die begins to melt, and perfect union is secured, cold water is dashed upon the die and head; and thus we have a sharp die, with an iron head, to sustain the force of the blow in stamping the plate, and by this means preventing any spreading of the face of the die or liability of breaking in the process of swaging.

"I now take sheet lead of the thickness of about No. 24, standard gauge, and adapt it to the face of the die by means of a wooden mallet or burnisher, or other convenient means. Trim the lead plate to the size required for the plate to be stamped; when the lead plate is nicely fitted, remove it carefully from the die and place it in a ring or narrow molding flask, the palatal side up; now gently stamp molding sand into the plate and flask, up level with the edges of the flask; then reverse the flask and cut the sand away *clean* for half an inch or more down to the edge of the lead plate all around. Around the plate place

a common molding ring sufficiently large to form the counter, which is made by pouring melted tin or lead (or any alloys of these metals) on to the lead plate, being careful not to run the metal so hot as to melt the lead plate. When the counter is cool enough to handle, the adhering sand is brushed or washed away; the die is then placed into the bed or counter, and, with a moderate-sized hammer, give one or two sharp blows to bring the die and counter together. In swaging gold plates, two, three or more dies may be required; these may be made either by running the die metal into the impression (if not broken) or by running into lead plates, gotten up as before described, reserving, of course, the first die and counter for the final swaging of the plate. I have gotten up a die and counter from the impression, with the aid of an assistant, in the foregoing manner, in twelve minutes. I usually get out my die immediately after taking the impression; adapt a wax or gutta-percha plate to the die, and get the articulation before the patient leaves the office."

In the act of contracting, the central portion of the die, being the last to solidify, is gradually drawn toward the periphery, forming, when the contraction is completed, an excavation of greater or less depth in the center of its base, a form unfavorable to an equal distribution of the force applied in swaging, and greatly increasing the danger of distorting the face of the die by cracking or spreading, especially when zinc is used. To concentrate and equalize this force is a matter of the first importance. The liability to such an accident may, to some extent, be avoided by placing on the die a cone-shaped cap of any hard metal, as zinc, brass, or cast iron. This, however, while it provides against one-sided blows of the hammer, affords only a partial remedy, since the same danger of spreading the die exists, in consequence of the cap resting on the outer border of the base of the die, with no central bearing whatever. To equalize the force perfectly, the cone-shaped metal cap should be incorporated with, and form part of the body of, the die itself. This is partly, if not wholly, accomplished by Dr. Franklin's expedient.

Counter-die.—A counter to the die is generally obtained directly from the latter. 1. The die is placed, face upward, upon

the molding board, and sand, prepared as in molding, built up around it, leaving only the ridge and palatal face exposed. It is then encircled with a cast- or sheet-iron ring two or three inches deep, its edge imbedded in the sand to prevent the escape of the fluid metal; into this the metal for the counter is poured until nearly or quite full.

The metal commonly employed for the counter is lead, although other substances, as tin, type-metal, some of the more fusible alloys hereafter to be mentioned, etc., are sometimes employed. When the counter is taken by pouring the metal or metals composing it upon a die fusing at a low heat, some caution should be observed lest the two pieces adhere by partial fusion of the die. In such cases the surface of the die should be well protected with lamp-smoke or whiting, the lead should be poured at the lowest practicable temperature, and the conduction of heat facilitated by surrounding the die with a heavy cast-iron box or ring.

During the process of forcing a plate into adaptation to the form of the mouth with swages, it not infrequently happens that the marginal portions of the former become wedged or immovably fixed between the outer border of the die and corresponding portions of the counter before its central portion is forced into contact with the palatal surface of the former, thus rendering it difficult to conform the plate accurately to the parts without the application of sufficient force to deface or otherwise mar the form of the die. In such cases the central portion of the plate may be first swaged with a *partial counter*, which is made to receive only the palatal portion and upper surface of the ridge of the die. This method, as practised and described by Dr. I. N. Broomell, of the Pennsylvania College of Dental Surgery, is as follows:—

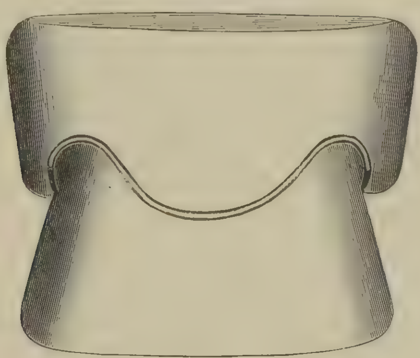
Progressive Counter-dies.—"It being desirous, in swaging a plate, to have the palatine portion forced into position at the beginning, the *first* counter-die should be formed as represented in Fig. 76. To accomplish this the sand must be built entirely over the ridge, allowing only the palatine portion of the die to be exposed. The *second* counter-die should extend just beyond the center of the ridge, as shown in Fig. 77, and the *third* or

final counter may be formed in the usual manner, see Fig. 78. By the judicious construction of this series of counter-dies, more satisfactory results are obtained, and much needless use of the horn mallet dispensed with. It will readily be observed that a counter-die formed as represented in Fig. 76 will drive the center

Fig. 76.

Fig. 77.

Fig. 78.



of the plate into position without the usual resistance experienced in using the ordinary counter. The use of No. ii (Fig. 77) will gradually start the plate over the ridge, and No. iii will readily complete the process."

As before remarked, preference is usually given to lead in the formation of a counter-die, mainly on account of its greater softness. This property in a counter is practically important. In

the process of forcing a metallic plate into adaptation to the mouth, partial displacement or yielding of either the die or counter, or of both, necessarily occurs, and it is scarcely necessary to remark that whatever change of form is produced should take place wholly in the counter, otherwise deformity of the die must ensue.

Essential Properties of a Die.—There are certain properties which it is indispensable that a metallic die should possess in order to answer fully the requirements of the dentist.

1. A die should be sufficiently *hard* to resist any necessary force applied to it in stamping the plate without suffering any material change in the form of its face, by which latter term is meant that portion of the die with which the plate is brought in contact. This property is most indispensable in those cases where the arch of the mouth is very deep, the rugæ prominent and sharply defined, and where the alveolar ridge is marked by angular and abrupt prominences and depressions. In such cases, if the die is not sufficiently resistant, the points most prominent upon its face will be bruised or battered down, while the plate will fail to be forced perfectly into the cavities or depressions, and its coaptation to the mouth, to that extent, rendered faulty. The case in which a less degree of hardness is admissible is where the arch of the mouth is broad and shallow, the rugæ imperfectly defined, and the ridge regular and symmetrical. The conformation of the mouth, therefore, will, in respect to the property of hardness, admit of some latitude in the choice of the metal or alloy employed in the formation of a die.

2. Another important property of a metallic die is *non-contraction*, so far, at least, as this is attainable. Inasmuch as the successful adaptation of the plate depends, in a great measure, upon an accurate representation of the precise form of the mouth in the die, it is of the first importance that the latter, other requisites being secured, should be composed of some metal or metals having the least possible contraction in cooling. Contraction is, in varying degrees, common to all metals exposed to a decreasing temperature, and it is impossible, therefore, to obtain a perfectly faultless copy of the mouth in metal. Fortunately, as well for the expert as the unskilled manipulator, the unavoid-

able shrinkage incurred is partially or wholly compensated for, by the expansion of the plaster model and the yielding condition of the soft tissues of the mouth, but under no circumstances should the accommodation afforded by the condition last mentioned encourage negligence or unskilfulness in the use of all available means necessary to secure the most accurate adaptation of the base. Ordinarily, a moderate degree of contraction will not materially impair the fit of a plate; on the contrary, in the case of the upper jaw, it sometimes favors its adhesion and retention in the mouth. Cases, on the other hand, frequently occur where the least practicable amount of shrinkage, even at the partial sacrifice of other properties, becomes indispensable in the die.

3. A third important requisite of a die is *fusibility*. Aside from the convenience incident to the use of metals which fuse at a low heat, there is another consideration favoring this property of more practical importance. It is well known that all metals expand by heat and contract by cold. In obedience to this law, metals fusing at a high heat suffer a greater aggregate contraction than those melting at a lower temperature, and, as between two metallic bodies of equal dimensions, liquefying at different temperatures, the difference in contraction will correspond exactly with the difference in the number of degrees through which each passes from the point of solidification to the mean temperature of the air, allowance being made for the difference in their ratios of contraction. Two dies, one composed of copper and the other of zinc, will serve to illustrate. Fused copper solidifies at 1900°. In cooling, therefore, it contracts through over 1800° to reach a working temperature, while zinc, fusing at 773°, contracts through only about 700° to reach the same temperature. As before stated, the difference in the contraction of metals will be somewhat modified by that in their ratio of contraction, but it will always be found that the more fusible metals have the least aggregate shrinkage whenever any considerable disparity exists between their fusing points. It is in accordance with the principles here set forth that the more fusible alloys, some of which melt at remarkably low temperatures, are employed whenever it is important to obtain a die as nearly the exact counterpart of the model as possible.

4. Finally, a die should be sufficiently *cohesive* to resist the repeated blows of a heavy hammer without parting or cracking. Many metals, as antimony, bismuth, etc., in other respects suitable for dies, are objectionable on account of brittleness. But it must not, therefore, be inferred that all metals that are denominated brittle are inadmissible for this purpose; for zinc, which in its ordinary condition is ranked as a brittle metal, and type-metal, which is always so, are in no danger of being forced asunder or of suffering displacement when in the compact form of a die, provided the force used in swaging is judiciously applied, or proper form and sufficient depth are given to the body of the die.

To recapitulate briefly: a die should be formed of some metal or alloy that has a surface hardness sufficient to resist compression; that fuses at a low temperature; that does not, in any material degree, contract in the act of cooling; and whose particles adhere with sufficient cohesive force to maintain perfectly its integrity of form under the hammer. Any one or two of these properties are readily attainable in the same die, but no one known metal or alloy combines all of them perfectly. Thus either cast-iron, brass, bronze, or cannon metal would form an excellent material in respect of surface hardness, and in the compact form of a die would be sufficiently cohesive, but few enjoy convenient facilities for melting them; besides, their great contraction consequent upon their high fusing point would render their employment entirely inadmissible. Again, certain alloys, as those composed of lead, tin, and antimony or bismuth, are eminently suitable on account of their ready fusibility and comparative exemption from shrinkage, but they gain these properties at the expense of that degree of hardness necessary to resist compression. Tin in its uncombined state is ordinarily sufficiently fusible, tenacious, and non-contractile, but is too soft and yielding when forcibly compressed. Antimony and bismuth are sufficiently hard, fusible, and non-contractile, but are objectionable on the score of extreme brittleness.

Any metallic substance that combines most perfectly the several properties referred to is, therefore, best adapted to the necessities of the mechanical operator, and experience has almost

universally accorded pre-eminence in this respect to zinc. It presents a more resistant surface to the blow of a hammer than either copper or brass, three times more so than that of tin, and more than double that of type-metal. As it usually occurs in commerce it may be classed as a brittle metal, but when annealed it is tough and malleable. It melts at a heat (773°) which may be readily commanded, and contracts but little in cooling. The late Professor Austen demonstrated by actual experiments that an average-sized zinc die measuring two inches transversely contracts $\frac{27}{1000}$ of an inch from outside to outside of the alveolar ridge, being equivalent in thickness to three ordinary leaves of a journal. Professor Austen remarks: "In the first case (upper jaw) the plate would 'bind,' and if the ridge were covered by an unyielding mucous membrane it would prevent accuracy of adaptation. In the second case (under jaw) the plate would have too much lateral 'play,' and consequently lack stability. Again, in a moderately deep arch, say half an inch in depth, the shrinkage between the level of the ridge and the floor of the palate will be nearly $\frac{7}{1000}$—rather more than one leaf of a journal. In the deepest arches this shrinkage becomes a serious difficulty; in the shallower cases it is not of much moment, as there is no mouth so hard as not to yield the $\frac{1}{1000}$ or $\frac{2}{1000}$ of an inch."

As before stated, a moderate degree of shrinkage in the die may, in certain conditions of the mouth, practically favor the adhesion and permanent retention of a plate applied to the upper jaw. The conditions alluded to, and which prevail in a greater or less degree in all cases, are, soft and yielding ridge and comparatively hard and unimpressible palate. Now, if in the first instance the plate is swaged into uniform contact with all parts of the jaw, it will be readily perceived that if pressure is made over the ridge on one side the latter will yield, while the central portion of the plate, meeting with a fixed point of resistance at the floor of the palate, will "ride" upon the latter, and thus throw the plate from the ridge on the opposite side of the jaw. If, however, a space equal to one or two thicknesses of the plate exists between the latter and the roof of the mouth, as a consequence of contraction in the die, the plate, as it is carried against

the palate, in the act of exhausting the air from beneath it, will at the same time forcibly compress the ridge, securing thereby a more resistant basis along the border, and providing more certainly against displacement of the base on the application of forces brought to bear upon it in mastication.

The extent to which the shrinkage of a die may be admitted in any given case will depend partly upon difference in the conditions heretofore mentioned in the soft parts of the mouth, and in part, also, upon the general configuration of the jaw. In a medium-sized mouth, with a depth of say half an inch to the arch, a moderately soft ridge and resisting palate, the shrinkage incident to zinc will be unimportant, and in many cases will be advantageous. If, however, the vault is very deep, even though there be a yielding ridge, the unavoidable contraction of a zinc die will throw the plate so far from the arch as to render it difficult for the patient to exhaust the atmosphere from between it and the floor of the palate, and even when the latter is practicable, the plate will bind with such force upon the outer border of the ridge as not only to produce pain and irritation of the compressed parts, but the resistance afforded at these points will be sufficient, in many cases, to break up the adhesion, and force the plate from the palate. Again, as an extreme case, if the ridge and palate are somewhat uniformly unyielding, and the palatal vault is at the same time very deep, a zinc die can only be made available in bringing the base as nearly into adaptation as possible, after which the operation may be completed with a swage having a less degree of shrinkage, and which, as a mere finishing die, need not necessarily be so hard as zinc.

In conforming a plate to the lower jaw, the die should be as free as possible from contraction in all cases. The greatest shrinkage in such cases will be between the posterior extremities of the ridge, giving too much lateral play to the plate; in addition to which the posterior and inner edge of the base, projecting out from the ridge, will obstruct the free action of the tongue, while the latter will tend to lift it from the ridge and render it unstable. These conditions may be partially remedied by turning the edge of the plate in against the ridge with pliers; but this expedient should never be resorted to in any case

whenever it is practicable to secure a correct adaptation by swaging.

In all cases in which a zinc die fails to bring the plate into proper adaptation to the parts, either of the following metallic compounds may be used to complete the process after partial stamping with zinc.

Type Metal.—Lead, five parts; antimony, one part. Fuses at 500°; contraction less than one-half that of zinc; more compressible than the latter and very brittle.

Babbitt or Anti-Friction Metal.—Copper, three parts; antimony, one part; tin, three parts. First fuse the copper, and then add the antimony and tin. Melts at a moderately low heat; contracts but little; is brittle, but may be rendered less so by adding tin.

Zinc, four parts; *tin*, one part. Fuses at a lower heat, contracts less in cooling, and has a less surface hardness than zinc.

Tin, five parts; *antimony*, one part. Melts at a lower heat than either of the preceding alloys; contracts but slightly in cooling; is harder than tin and sufficiently cohesive. It is readily oxidized and should be poured as soon as melted.

Fusible Alloys.—The following tabular view of the more fusible alloys, the respective properties of which are deduced from actual experiments, was given by Professor Austen in a paper on "Metallic Dies."* Zinc is introduced into the table for the purpose of comparison.

	Melting point.	Contractility.	Hardness.	Brittleness.
1. Zinc,	770°	.01366	.018	5
2. Lead, 2, Tin, 1,	440°	.00633	.050	3
3. Lead, 1, Tin, 2,	340°	.00500	.040	3
4. Lead, 2, Tin, 3, Antimony, 1,	420°	.00433	.026	7
5. Lead, 5, Tin, 6, Antimony, 1,	320°	.00566	.035	6
6. Lead, 5, Tin, 6, Antimony, 1, Bismuth, 3,	300°	.00266	.030	9
7. Lead, 1, Tin, 1, Bismuth, 1,	250°	.00066	.042	7
8. Lead, 5, Tin, 3, Bismuth, 8,	200°	.00200	.045	8
9. Lead, 2, Tin, 1, Bismuth, 3,	200°	.00133	.048	7

Professor A., in commenting on the preceding table, observes:

* *American Journal of Dental Science*, vol. VI, page 367.

"The last column contains an approximate estimate of the relative brittleness of the samples given. As in the other columns, the low numbers represent the metals, so far as this property is concerned, most desirable. Those marked below 5 are malleable metals ; those above 5 are brittle ; zinc, marked 5, separates these two classes, and belongs to one or the other, according to the way in which it is managed." Allusion is here made to the process of annealing zinc, which has already been adverted to when considering the latter metal in the former part of the work. The special method employed is thus described by the author already quoted : "The simplest way to anneal a zinc die is to place it in the melting ladle with about a tablespoonful of water, removing it in thirty seconds after the water has boiled away. If the fire is a very hot one, remove it immediately on the disappearance of the water. It will often happen that the die is annealed in the process of taking the counter-die. This will more certainly occur when Nos. 7, 8, or 9 (see table) are used for the counter. For example, take tin, using a mass twice the size of the die ; should it be heated to 540° (100° above melting point), it would not, allowing for loss of heat by radiation and contact with the cast-iron ring (if one be used), heat the zinc beyond 330°. Lead, cast as cool as it could possibly be poured, unless in a very heavy ring (such as a 'cart-wheel box'), or in quantity too small for a well-shaped counter, would be apt to raise the zinc at least 400°, and so impair its malleability, whilst, if poured as hot as many are in the habit of doing, the zinc will remain as brittle as when first cast."

CHAPTER V.

PARTIAL DENTURES.

The almost unlimited modifications in the form of substitutes designed to supply the loss of a portion only of the natural teeth and the difficulties oftentimes incident to a harmonious arrangement of the teeth of replacement, as well, also, as the impracticability of always securing a perfectly satisfactory and efficient antagonism or closure of the artificial with the natural organs, frequently surround this process with peculiar embarrassments, and often render their successful application extremely difficult. They will, accordingly, be found to demand of the operator the exercise of greater skill, ingenuity, and discrimination than are usually required of him in the construction and application of entire dentures.

Certain general and characteristic forms of substitutes of the kind under consideration derive their distinctive character from the several means employed in fixing or retaining them in the mouth. These means of retention may be classified as follows:—

1. The roots of the natural teeth as supports for single artificial crowns, and for so-called bridge-work.
2. Clasps attached to the remaining natural teeth.
3. Atmospheric pressure and adhesion.

Crown- and Bridge-work.

Introductory Remarks.—Under the first head given above, for supporting partial artificial dentures, the various methods of constructing and attaching single artificial crowns, and the allied method of replacement known as bridge-work, will be considered.

Though the proper construction of a modern collar crown or bridge denture requires much scientific information, unusual skill, and sound judgment, a great portion of the work entailed is necessarily done in the laboratory. It should, therefore, have

a place in every work embracing the subject of prosthetic dentistry. It demands, in fact, a distinctive place, as it is one of the most important and exacting branches of dental practice.

As Dr. George Evans has well said, modern crown- and bridge-work, properly understood and properly performed, takes high rank in dental art, and offers wide scope for versatility of talent and inventive genius. The varied and complicated cases presented for treatment frequently suggest to the expert novel contrivances and methods of construction and application. Successful practice of crown- and bridge-work depends upon a thorough mastery of the underlying principles, and expertness in the processes involved, governed by sound judgment and perfect candor. When practised by dentists possessing the requisite attainments and governed by correct ethical principles, it gives results which are gradually establishing its value, removing erroneous impressions, and insuring a wide professional and public indorsement.

There are, however, limits to the utilization of these means of support. There are many roots wholly unsuitable for the purpose. The operation may be said to be valuable in proportion as the artificially-crowned root can be made comfortable, serviceable, and durable. A pulpless root that is extensively disintegrated, or that is greatly denuded from excessive absorption of the surrounding alveolus, or very loose in consequence of extended destruction of the investing membranes, cannot, in any sufficient degree, meet these requirements. Between these extreme conditions on the one hand, and those associated with partially crownless roots with the pulp intact, the investing membranes free from disease, the cervical portions of the bony structure unimpaired by decay, and a firm attachment to the socket, conditions representing, on the other hand, an opposite extreme, there are graduations of normal and abnormal states, which, while they may not exclude the operation, must, in some degree, impair its value. Any estimate of the absolute value of this method of substitution that excludes a recognition of this fundamental truth is a false and unwarranted one, and there can be no rational prognostication in these cases that does not admit this truth as an essential element in forecasting results.

Not only will results be modified by conditions immediately associated with the root to be operated on, but also, to some extent, by the general health of the mouth. Any abnormal states of either the hard or soft tissues, or the presence of foreign deposits, will act as predisposing causes in the development of unfavorable conditions whenever the root operated on has, previous to curative treatment, been morbidly affected, and especially if such diseased conditions have been somewhat virulent and of long standing. It is best, therefore, in all cases to inspect the mouth carefully before attaching the crown, and if any of the remaining teeth are found carious or incrusted with tartar, or the mucous membrane and gums are inflamed or otherwise diseased, appropriate treatment should be directed to the correction of such abnormal conditions as may be present.

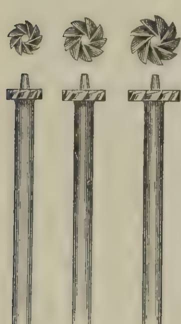
In the less favorable class of cases, or where the root has been previously diseased, though subsequently restored to a healthy condition, any diathesis or constitutional tendency predisposing to inflammation or suppuration, may become a factor in the development of unfavorable results. Whenever this predisposition exists in any marked degree, the operation should be performed in the most careful manner, avoiding as far as possible all sources of irritation in the use of stones, saws, drills, and in tapping and malleting, and especially in the use of excising forceps for the removal of any remaining portions of the crown. Should any tenderness or loosening of the root supervene after its necessary preparation, and before setting the crown, it will be prudent to defer the completion of the operation until there is a subsidence of the morbid conditions, for, if by reason of such irritation or inflammation, suppuration should be re-established, it may be necessary to free the pulp canal and renew treatment through the apical foramen.

The success of the operation may also be greatly impaired by careless, hurried, and injudicious manipulation; as where the remaining portions of the natural crowns of the tooth are violently removed with excising forceps, by the unskilful use of instruments in dressing the root, by drills in enlarging the central cavity, by undue or misapplied force in the final adjustment of the artificial crown, or, finally, by a faulty position of

the tooth of replacement, by which the root is subjected to injurious strain, either by lateral pressure or premature closure against those of the opposite jaw. By the operation of either or all of these causes, disease of a more or less intractable character may be induced which will impair the usefulness of the artificial organ and subject the patient to much annoyance.

Preparation of the Root.—In the process of preparing the root for the attachment of an artificial tooth, all remaining portions of the natural crown should first be removed with suitable instruments. If the cervical portion of the tooth is comparatively sound and unbroken, this may be most expeditiously accomplished, and with less risk of injury to the root, by cutting two parallel grooves, opposite each other, on the labial and palatal surfaces, with a small circular saw, or a hard rubber or rubber and corundum disk. These grooves should be cut through the enamel deep into the dentine. Then with the excising forceps, the cutting edges of which are placed in the grooves, the crown is readily severed from the root.

Fig. 79.



After the use of the disks and excising forceps, any remaining portions projecting beyond the free margins of the gum should be removed and proper shape given to the end of the root. A flat-edged corundum stone or what are known as the Ottolengui root facers (Fig. 79) are the best for the purpose, and when in use the stones should be kept constantly wet and free from clogging particles of tooth substance. The end of the root should be dressed down, anteriorly, a little below the free margin of the gum, care being taken not to cause unnecessary laceration; in this way the artificial crown, when adjusted to the root, will unite so intimately with the gum in front, in ordinary cases, as to render exposure unnecessary. The surface of the root prepared in this manner will present a concavity corresponding with the festoon of the gum.

If a living pulp remains in the root, it will not ordinarily be practicable,—unless there is partial obliteration and consequent

recession of the pulp cavity as the result of ossific deposits,—either to cut off the tooth on a line with the gum or even transversely, or to dress the root even with the gum, without inflicting insufferable pain. It will be necessary, therefore, under such circumstances, either to devitalize, and extirpate the pulp through the carious opening in the crown before the latter is removed, or (if not exposed by excising the tooth), through an opening into the pulp, made with a drill revolved by the dental engine, after excision.

Devitalization of the Pulp.—There are several ways of extirpating a dental pulp. One of the older and still not uncommon methods of operating consists, first, in devitalizing it with arsenious acid and then removing it with a broach. Another method practiced by some is to thoroughly expose the pulp, apply cocain and then extract the pulp with a broach.

Excision of Crown and Instantaneous Extirpation of the Pulp.—A somewhat heroic method, though one with which the writer has had much satisfaction, by which a living pulp may be quickly and successfully removed, with comparatively little pain, consists in cutting the labial and palatal grooves as has been directed, making them as deep as possible, without inflicting too much pain; then with the excising forceps, the cutting edges of which are inserted in these grooves, the crown is quickly severed from the root. This usually leaves the pulp fully exposed and paralyzed, when a piece of orange wood—previously cut and shaped to about the size of the canal, not larger, and the point saturated with carbolic acid—is carefully placed against the exposed point of the pulp and quickly driven with one light blow from the mallet into the pulp canal. When the wood is withdrawn, the pulp often adheres to it; if not, it may be quickly and painlessly removed with a broach. In this operation the immediate paralysis induced renders it comparatively painless.

Preparation of the Pulp Canal.—After the removal of the pulp the apical foramen should be thoroughly closed by any method usually employed in root filling. A neglect of this important measure will greatly endanger the success of the operation.

The proper treatment and preparation of the root having been thus far accomplished, the canal of the latter should next be enlarged for the reception of a dowel-pin. This is effected with an ordinary fissure drill or the Ottolengui root reamers (Fig. 80).

Fig. 80.

The natural opening in the root should be enlarged to the depth of two or more lines, according to the length of the root; and the orifice should be made large enough to admit a support of sufficient size to secure the crown firmly in position. The direction of the drill in cutting should follow closely that of the natural canal in the root, since but a slight deviation in this respect may endanger the integrity of the latter by too great a thinning, or actual perforation, of its walls. The face of the root should then be given a suitable shape for the reception of the form of crown to be attached, the methods of fitting and inserting which will now be considered, the simple or all porcelain system being first taken up.

Porcelain Crowns.—The system of using all porcelain crowns has a number of advantages, and at the same time there are strong reasons, we think, for using another system—known as the ferrule or collar crown—in all favorable cases.

The porcelain crown is especially useful where an inexpensive and quickly adjusted crown is necessary; or where some pathological condition would seem to limit the probable permanency of an operation, or, again, where a temporary crown is desired to serve, as is sometimes necessary, until the patient or operator can make suitable engagements for more permanent work.

The objections made to the use of this class of crowns for permanent work is, the pin or post upon which almost the entire support of the crown is thrown acts as a lever in the root canal, and sooner or later many of the weaker roots are fractured, thus ending their usefulness as a support; and again, the pin or post, entering, as it does, deeply into the body of the porcelain, weakens it at this point, and not infrequently do patients return with the crowns fractured through the center, from the force of mastication. Then again, when the crowns are set with amalgam, which is the practice of many, the discoloration of the line of

union with the root, if subsequently exposed, is very objectionable.

The all-porcelain crowns may be divided into two classes: First, those having one end of the pin or post baked in the porcelain when the crown is made, such as the Logan, Brown, and new Richmond; second, those attached to the root by a pin, post, or screw, one end of which is first cemented in the root and the other afterward to the crown. Of this class we have the Bonwill, How, Gates, Foster, and Howland.

After deciding upon the form of crown to be used, one should be selected to correspond as nearly as possible in size and general configuration with its fellow on the opposite side, and to harmonize in color with those immediately adjoining. The manner of preparing and adjusting each of the crowns named will be taken up in the order given.

The Logan Crown.—The Logan crown, invented by Dr. M. L. Logan, is probably of all these the one most extensively used. The method of adjusting and mounting is given in all its details in the following article by Dr. W. S. How:—

"Fig. 86 shows a superior right central root, an end appear-

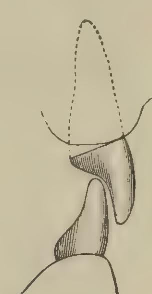
FIG. 81.

FIG. 82.

FIG. 83.

FIG. 84.

FIG. 85.



ance of the same, and a Logan crown, front view. Fig. 87 exhibits, at a right angle to the plane of the first figure, the same root, its end, and the Logan crown, side view. In both figures the root-canal is supposed to have been first drilled to a gauged depth with an engine twist-drill, No. 154, and then enlarged by means of a fissure-bur,

No. 70, to the tapering form shown; the walls being subsequently grooved with an oval bur, No. 90. The enlarged section (Fig. 88) shows the crown adjusted on the root by means of cement or

FIG. 86.

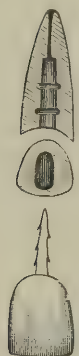


FIG. 87.

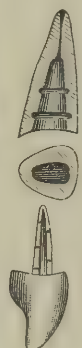


FIG. 88.

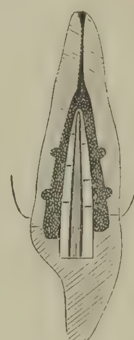


FIG. 89.

FIG. 90.

FIG. 91.

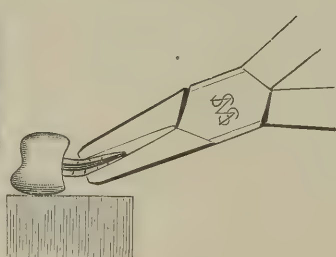


FIG. 92.

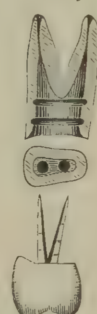


FIG. 93.

FIG. 94.

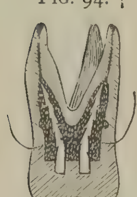


FIG. 95.

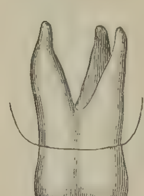
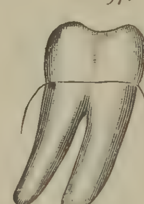


FIG. 96.

FIG. 97.



gutta-percha, which surrounds the post and fills all the spaces in the root and crown. Fig. 89 shows the completed crown. Fig. 90 exhibits a bifurcated bicuspid root, its end appearance, and a

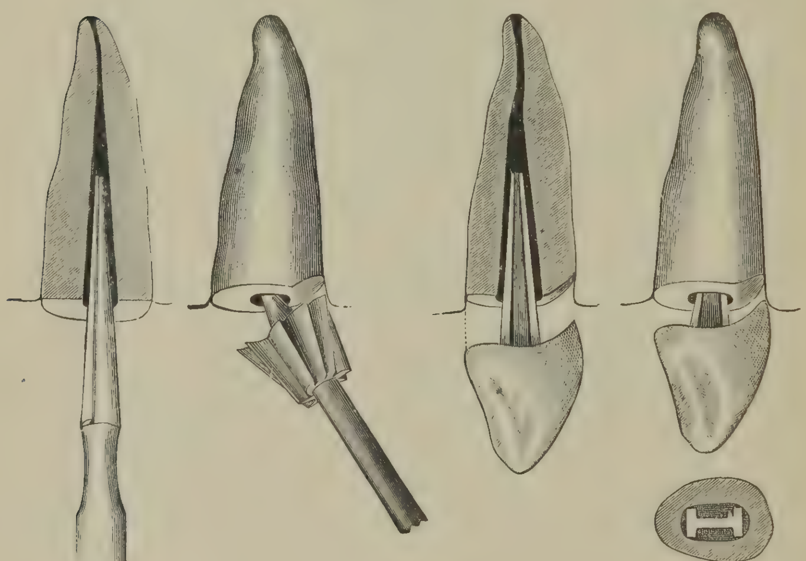
Logan crown adjusted to the root. Fig. 91 illustrates the best manner of bending the post. Fig. 92 shows a split post, and its adaptation to a bifurcated bicuspid root is seen in Fig. 93. Figs. 94 and 95 exhibit the mode of mounting the Logan crown on a superior molar root, and Figs. 96 and 97 the same crown in its relations to an inferior molar root.

"The preceding figures clearly present to the mind's eye of the expert dentist the essential features of the Logan crown and the method of mounting it.

"The details are as follows: In every instance where a root is deemed ready to receive its filling, it should first be measured through its canal from the cervical opening to the apical foramen, and this may be accurately done with a gauge adjustable on a delicate canal-explorer (Fig. 81). The same device serves to measure the distance from the apex to which the canal should then be filled (Fig. 82). It also gauges the depth to which the drill may be carried. The proper degree of enlargement from the bottom of the drilled hole will, of course, depend on the observed size and character of the root. Every dentist should familiarize himself with generic tooth-forms, so that when the length of an incisor, cuspid, or other tooth-root is known, he can so nearly determine its hidden outlines as to form with precision a corresponding enlargement of the root-canal, such as is shown by the several cuts. For preparing the roots, the Ottolengui root-reamers and facers (see pages 190 and 192) are very desirable instruments. The reamers are made in three sizes to correspond with the Logan pins. With a root-reamer of the appropriate size, the root-canal is enlarged to fit the pin along its whole length, and so hold the crown firmly, *independent* of the cement. With a root-facer a labial slope is given to the root-end, so that the crown neck shall fit under the edge of the gum. Fig. 98 shows the method and its result, and the cross-section shows how the cement incases the pin. The suitable preparation of the bifurcated roots of some bicuspids and of all the molars is a matter involving difficulties of an unusual character and requiring good judgment. The feasibility of splitting the post of a Logan crown to adapt it to the bifurcated root of a bicuspid is shown in Figs. 92 and 93. This example directs attention to the

peculiar shape of the post, in which there is effected such a distribution of the metal that its greatest strength is in the line of the greatest stress that will in use be brought to bear on the crown, while the least metal is found at the point of the least strain; the applied part of the post being in outline nearly correspondent to that of the root itself. The root-canal is likewise conformably enlarged to receive the largest and stiffest post which the size and shape of the root will permit.

Fig. 98.



"The fitting of a Logan crown to a root may be done with a wet stump-wheel in the engine hand-piece. A safe-side crown corundum-wheel (Fig. 99) can be used in the same manner. It also affords the greatest facility for the slight touches required to abrade the thin cervical borders of the crown, which may by this means be done without encroachment on the post.

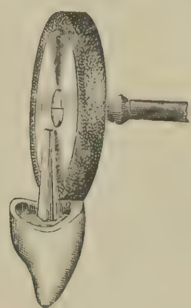
"By the old method of adapting pivot-teeth to roots, the close fitting of the crown precluded the use of a plastic packing, because its thinness over the surface of the joint made the packing liable to break loose under the shock and strain of use. The

recess in the Logan crown obviates this defect by providing a receptacle for a considerable interior body of cement that will be deep enough to be self-sustaining internally, and yet allow the peripheral portions of the root and crown to approach each other so closely that, though only a film of packing remain, it will still be strong enough to insure the persistent tightness of the joint. This annular boss if formed of amalgam also adds strength in some cases to the mount.

" When enough of the natural crown remains, it is well to leave standing some of the palatal portion, and cut the root under the gum-margin at only the labial part, as shown by Fig. 83.

FIG. 99.

FIG. 100.



The safe-side crown wheel is especially useful in such cases (Fig. 100). Thus the labial joining of the root and crown will be concealed, and the other parts of the joint will be accessible for finishing and keeping clean (Fig. 84). The Logan crown may be ground until a large part shall have been removed for adaptation to the occluding tooth or teeth without seriously impairing its strength (Fig. 85). This crown also in such cases maintains the translucency, which is one of its peculiar excellences, owing to its solid porcelain body and the absence of a metallic backing or an interior largely filled with cement or amalgam.

" The distal buccal root of the natural superior molar is nearly always too small to receive a post of any useful diameter, and therefore the Logan superior molar crown has but two posts, which, like those of the inferior molar crown, are square, and thus

may be easily barbed, as may also the ribbed posts of the crowns for the anterior tooth-roots. These posts are large enough in all the Logan crowns to answer in any given case, and can, of course, be easily reduced to suit thin or short roots.

"Any of the cements or amalgams may be used in fixing these crowns, but good gutta-percha, softened at a low heat and quickly wrapped around the heated crown-post, which is at once seated in the root, forms the best mounting medium, and has the great advantage of permitting a readjustment, or, if need be, the ready removal of the crown by grasping it with a pair of hot pliers or forceps, and holding it until the gutta-percha is sufficiently softened."

The Brown Crown.—This crown, invented by Dr. E. Parmley

FIG. 101.

FIG. 102.

FIG. 103.

FIG. 104.

Brown, is shown in Figs. 101 to 104. Fig. 101 gives a lateral view of a porcelain crown, with an iridio-platinum pin baked in position. The pin has great strength at the neck of the tooth, where the strain is heaviest, and this strength is further increased by extending the porcelain up on to it, as shown in the accompanying illustrations.

A front view of the same crown is illustrated in Fig. 102. The dotted lines show the shape of the pin and the position which it occupies in the crown.

The pin is flattened laterally, affording a strong hold in the porcelain without bringing it too near the surface in thin teeth, while it also permits alteration of the palatal surface of the crown in a close "bite" without risk of weakening the body.

Fig. 103 is a view of the bicuspid crown, in which two pins are provided, one for each root of two-rooted bicuspids.

Fig. 104 is a view of the same crown with the two pins pressed

together, forming a single pin of great strength for a single-rooted bicuspid.

The double pin in the bicuspids prevents the gradual loosening of the crown by the rotary movement of the jaws in mastication, which, acting on the two cusps, exerts such leverage as to sometimes turn and break down ordinary crowns where only one pin is used.

The roots are ground concave to fit the crowns with corundum-points or a Willard countersink bur, and close joints are made well under the gum, the pins being set with oxyphosphate cement. The canal should be enlarged just enough to admit the pin, which should fit snugly throughout its entire length, the

FIG. 105.

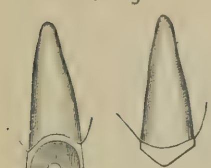


FIG. 106.

FIG. 107.

better to distribute the leverage exerted by the crown, and thus directly to increase the strength of the attachment.

The New Richmond Crown.—Dr. George Evans, in his treatise on "Crown and Bridge Work," describes the new Richmond crown as follows: To illustrate and describe the method of mounting this crown, a superior left central incisor root will serve as a typical case, and its projecting end is to be shaped as seen in Figs. 105 and 106. This can be rapidly done with a narrow, safe-sided flat or square file, the angles of the slopes being such, that the gum on the labial and palatal aspects will not interfere with nor be disturbed by this preliminary work, as the root-end is not, in this operation, to be cut quite down to the gum. An Ottolengui root-reamer No. 2 is then employed to bore out the root to receive the crown-post, which is of the same size and shape as the Logan crown-post for a central incisor.

The sectional view (Fig. 107) shows the relation of the reamer

to the root. The new Richmond crown (Fig. 108) is then tried on the root (Fig. 109), and its position relative to the adjacent and occluding teeth noted. If the cutting-edge of the crown is to be brought out for alignment with its neighbors, the root can be drilled a little deeper, and the reamer pressed outward as it revolves to cut the labial wall of the cavity. The palatal root-slope must then be filed to make the V correspond to the changed inclination of the crown.

Thus, by alternate trial and reaming and filing, the crown may be fitted to the root and adjusted in its relations until the post has a close, solid bearing against the labial and palatal walls of the enlarged pulp-chamber, and the crown-slopes are separated from the root-slopes by the thickness of a sheet of heavy writing-

FIG. 108.

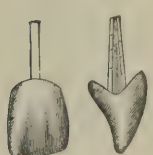


FIG. 109.

FIG. 110.

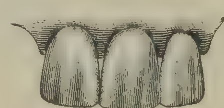
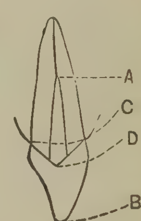


FIG. 111.



paper. This space can be accurately gauged, and the root-slopes conformed to the crown-slopes by warming the crown and putting on its slopes a little gutta-percha, so that an impression of the root-end may be taken, and the root-slopes dressed with a file until the film of gutta-percha proves to be of equal thinness on both slopes.

To permanently attach the crown, Dr. Richmond usually takes a thin, perforated disk of gutta-percha, pushes the post through it, warms the crown, presses it into place, and when cooled removes it, and with a sharp knife trims away the gutta-percha close to the crown-neck. He then warms the crown, puts a very little oxyphosphate cement on the post, and presses the crown home. Fig. 110 shows the completed crown.

The obvious advantages of the device are the readiness with which the slopes of the root-end may be shaped with a file; the

facility with which these slopes may be given any angle to set the crown out or in at the base or at the cutting-edge, or to give it a twist on its axis; the certainty that, once adjusted, the final setting will exactly reproduce the adjustment; the assurance that in use the crown will not be turned on its axis, a most common cause of the loosening of artificial crowns; the firmness of its resistance to outward thrust in the act of biting. This is made apparent by Fig. 111, wherein it will be seen that in an outward movement the crown B would rock upon A as a pivot. The dotted line D shows how the crown-slope is resisted by the root-slope, which extends so far toward the incisive edge that a much firmer support is given to the crown than if the resistance should be, as it usually is, on the line of the gingival margin C.

FIG. 112.

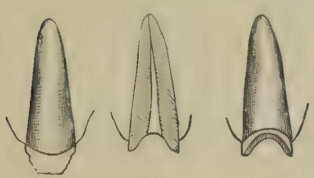
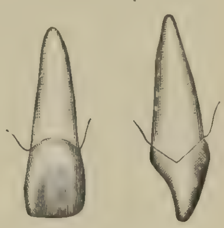


FIG. 113.

FIG. 114.



For roots that have become wasted below the gum-surface it is not suitable, except in such cases as are decayed under the labial or palatal gum-margin only, but have yet projecting the approximal portions of the crown (Fig. 112).

The sectional view (Fig. 113), and the perspective plan views (Fig. 114) illustrate the manner of mounting these crowns on this class of roots. The finished crown appears as in Fig. 114.

The cases for which this crown seems specially adapted are such as have some considerable portion of the natural crown remaining.

The Bonwill Crown.—This was one of the first crowns introduced in improved porcelain crown-work. The process of its adjustment and insertion is explained in a lengthy article by its inventor, Dr. W. G. A. Bonwill, from which the following is presented:—

" These all-porcelain crowns have three distinctive features: a concave or countersunk base; a triangular opening from the base to a point at or near the cutting-edge of the incisors, the base presenting to the labial surface (at its upper portion this groove is enlarged); a peripheral margin or border resting perfectly flat on the root, the concavity of the base on the palatal side being at a much more acute angle than on the approximal sides. An anchorage is made in the incisors by a depression or

FIG. 115.

FIG. 116.

FIG. 117.

FIG. 118.

FIG. 119.

FIG. 120.

FIG. 121.

"Fig. 115.—Sectional view of an incisor crown from mesial side, showing the undercut at the point opening on palatal surface, the conical base, and the opening of the same to the retaining-grooves, with the exact relations.

"Fig. 116.—Palatal view of same tooth. *a* is the external opening for egress of alloy and for packing around the pin. The dotted lines show the recess or undercut on the mesial and distal sides and near the point for retaining the crown, and its relation with the conical base.

"Fig. 117.—Grinding-surface view of a superior molar with the countersunk pin-holes on the buccal and palatal sides.

"Fig. 118.—Same view of an inferior molar with the pin-holes on the mesial and distal sides.

"Figs. 119 and 120.—Sectional views of a molar and a bicuspid crown, showing the countersinks and their relations with the conical base.

"Fig. 121.—Sectional view of an incisor root, showing the retaining-cuts made by the wheel-bur shown in Fig. 128."

undercut between the labial and palatal surfaces, opening on the latter. In the bicuspids and molars the retaining-pits are nearer the grinding-surface.

" The concave base of the crown prevents the amalgam from escaping under the heavy pressure exerted to force it into position, and in impacting the amalgam and expressing the mercury. It allows of a dense body of material around the metallic pin, giving the equivalent of a pin the whole diameter of the base of the crown. It leaves no joint, the crown and root being continuous. The amalgam is so thoroughly hardened at once by

impaction in the double concave of crown and root as to make a very firm operation. It prevents any possibility of the crown's twisting upon the pin and root. In the event of fracture of the crown, the convex surface of amalgam on the root makes the substitution of a new crown an easy operation. It enables the

FIG. 122.

FIG. 123.

FIG. 124.

FIG. 125.

FIG. 126.

FIG. 127.

FIG. 128.

"Fig. 122.—End view of a canal prepared for the improved combination-metal pin.

"Fig. 123.—End view of same canal as in Fig. 122, prepared for a triangular pin, showing how much more of the mesial and distal surface have been cut away from it than in Fig. 122 for the improved pin.

"Fig. 124.—Sectional view of an incisor crown and root, with the improved pin in its relative position to each,* with the depressions made by wheel-bur.

"Fig. 125.—Sectional view of a superior molar, with the large angular pin in palatal root and two square pins in the buccal roots, one being shorter and not passing through the crown.

"Fig. 126.—Block of a molar and bicuspid, showing the countersunk holes for pins in the molar, and the hole in the mesial side of the second bicuspid where a pin is alloyed in and set into a decayed cavity in the distal surface of the first bicuspid, being held upon the molar roots and attached to the bicuspid by the alloy.

"Fig. 127.—Side and end view of the largest-size angular combination-metal pin with the stamped serrations.† The square pins are without serrations and double-pointed, made of the same metal and of equal thickness throughout.

"Fig. 128.—The smallest-sized wheel-bur for grooving the canals for anchoring the pin and alloy."

---

* The sectional views of the incisor and molar, giving the relative position of the pins in the crowns and roots, should show pins of larger size. The pins as furnished should be filed down but little. It is not absolutely necessary that so many serrations should be made in the canals by the wheel-bur for retaining the amalgam and pin as are shown in the sectional view of the root of an incisor. While no serrations are shown in the roots of the molars, it is understood that all the canals must have the serrations. The square pins in the canals need no serrations. At the point where they occupy the countersink in the crowns, make two or three very slight cuts on the edges with a sharp file. The ends can be left blunt.

† These pins are now made without serrations. When amalgam is used for securing them, they become amalgamated and firmly united.

operator to fit the crown in much less time; it allows a proper position to be given to the pin, with less danger of fracture therefrom; it permits of a larger quantity of amalgam in the crown, and is capable of bearing greater strain; it makes the permanent success of the operation probable, from the fact that it is absolutely jointless, and secures immediate solidity, even while the amalgam is semi-plastic. These crowns are capable of resisting the force of biting or mastication, because they are supported nearly to the cutting-edge or grinding-surface, the triangular opening from the concave base nearly to the cutting-edge allowing the pin to be imbedded in the labial face of the crown where there is the greatest amount of porcelain.

"The amalgam to be used as the medium of union must set quickly and be very hard. Thus far I have found nothing better than the alloys I have specially prepared for this line of work, and, though they are costly, the superior results obtained by their use amply repay the cost. I use No. 1 generally. If mixed thick, it will set so quickly that the operator must work rapidly to prevent its being wasted. In incisor cases I use No. 3 at the gum line and make a close joint.

"In preparing the canal, use first a small-sized, spear-shaped drill, carefully following the natural channel. Then follow with a larger one, taking care not to cut through the root near the apex. On the mesial and distal sides cut away but little, as there is where fractures are most liable to occur. The canal can be very tapering and yet hold the pin. There need be but very little space around the pin. By all means save all the walls of the root possible. The smallest-sized wheel-bur may be used to make a thread at various points along the canal to hold the amalgam.

"If the patient exposes the gums much in speaking or smiling, the root may be cut down with the bur or corundum-wheel beyond the free edge, to conceal the joint. With bicuspids and molars it is not necessary to go below the gum; a joint well made will not be observed, and the strength of the root will be preserved. If the root is decayed below the gum, after removing the softened parts, fill it with alloy.

"It is not necessary that the face of the root should be flat; it may be either concave or convex, according to indications.

"It is advantageous to take an impression and 'bite' of the root, and make a model and articulation in plaster.

"The crown to be inserted should be inspected closely, as the retaining undercut in the incisors and the depressions in the bicuspids and molars may not be well defined. If not, the crowns are liable to work loose. If the base has been ground off in fitting, the edges should be beveled again to a fine margin with a corundum-point. The crown should be fitted to the root in the mouth, not to the plaster cast. The articulation should be clear, to avoid displacement. The pin should be as large as the previously prepared canal will admit. The pin must in every case be fitted, and in fitting it file only on the plain sides. Leave the end sharp, to offer the least resistance in passing through the amalgam. The end of the pin to be passed into the crown needs very little alteration. The crown, being open on the palatal surface of the incisors, permits a blunt-pointed pin to go up to its place. The middle of the pin should not be interfered with if it can be avoided. It is well to cut the pin a little short for incisors, as it may not get pushed entirely up in the root through the amalgam. Small square pins are used in the bifurcated roots of bicuspids and in the buccal roots of molars. They can be sharpened at both ends, but the outer end will not require so much sharpening. The palatal roots of molars will generally take one of the largest thick pins, with one square pin in the largest and most accessible buccal root. Each canal should have a pin, if the canal can be reached and properly prepared to receive it, even though the pin has to be so short as not to pass through the hole in the crown. If it enters the countersunk base it will support the root. The lower molars will require two of the largest-sized pins. As the support of the root is dependent upon the size of the pin and the depth to which it is inserted, single-rooted teeth should have the very largest thick pin. If the root is thin on the mesial and distal sides, the thin, angular pin is to be preferred. Ordinarily these large pins do not have to be bent. If necessary, it had better be done with a hammer and before the mercury touches them. The pin should have free movement in both root and crown. Should it be discovered that the pin is too long after it has been packed in the

root, it can be cut off with sharp forceps, pressing them up against the pin to prevent displacement. The pin can be sharpened subsequently with the corundum-wheel.

"To insure an amalgamation of the pin with the filling, brighten the surface of the former before inserting.

"The roots, crown, and pins being in readiness and arranged on the table, so that no mistake may occur from getting the pin in the wrong position, and the appliances necessary for the operation being at hand, the alloy preferred should be mixed a little thinner than if intended for a filling, especially where the root has a long canal. The shorter the canal, the thicker the amalgam may be mixed. Mix only enough at one time for one root. Put enough amalgam in the canal to nearly fill it, but do not pack it; force into it a steel pin made for the purpose, of about the same size as the pin, to make way for the easier insertion of the latter. Then grasp the pin with suitable forceps, and carefully but steadily press it up to its destination. If you cannot succeed in doing so, remove it, and again use the steel pin. When in place, use an instrument with a point small enough to pass between the pin and the root, and pack by tamping the amalgam around it. A piece of bibulous paper placed over the point of the instrument will assist materially in carrying the amalgam before it. Before the amalgam has become too hard, replace the crown to determine that the pin is in proper position; if not, it can be crowded to one side or the other with the tamping-tool. Should the pin be found to be rather long, it can be ground off with the corundum-wheel, holding it meanwhile with the forceps. No attempt should be made to bend the pin after it has been amalgamated, for fear of breaking it. If any amalgam has been left, and it is still plastic, it may be packed around the pin at the base of the root, using the bibulous paper as before directed. If not, mix again to complete the operation. Bank up the amalgam on the root high enough to fill the base of the crown. The crown should now be tried on, and forced home with an adjuster adapted to the case, removing the surplus amalgam if too much, or adding if not enough. Remove and dry the crown, and fill up simply the undercut cavity near the cutting-edge if an incisor, or the depressions in the crowns of

bicuspids or molars, allowing a very little to extend into the cervical base. Now force it home with the adjuster. It requires considerable force to set one of these crowns according to directions,—a force which cannot be applied with a mallet without danger of loosening or displacing the crown. Steady pressure with slight rotation will carry the crown into place, if the amalgam is not too hard or there is not too much of it. I would advise you not to attempt to set a crown without an adjuster or its equivalent. Free mercury will be squeezed out on the palatal surface, which should be wiped off. Now hold the crown in place with the fingers, with the bibulous paper under the tamping-instrument, and consolidate the amalgam around the point of the pin in the crown, absorbing any free mercury which appears there. The excess of alloy at the joint must now be removed, care being taken to press the crown up while this is being done. The amalgam packed around the pin in the crown on the palatal side should be as stiff as may be to work readily. It is well to leave over some of the first mixing for holding the pin, and this will be about right for consolidating about this point.

"If in a bicuspid or molar crown the pin should come so far through as to interfere with articulation, it may be ground off with the corundum-wheel while the crown is firmly held.

"The case can now be dismissed, with directions for the patient to return the next day, in order to make sure that the articulation is correct and to dress off the joint between the crown and root, which may be done with a small, round-headed bur.

"There are some cases in which the root cannot be filled with anything; if in a molar, the pulp-chamber can be relied upon to hold a headed pin or pins. When a tap-hole is required in the root it can be made low down and at an acute angle, and the amalgam packed around the root-canal above the tap.

"Should an artificial crown be broken, another can easily be substituted by burring off any excess of amalgam, and using fresh amalgam, mixed thin, to allow of ready adjustment.

"Two crowns can be inserted on the root of one large molar with the assistance of the decayed approximal surface of an adjacent tooth (see Fig. 126)."

The How Crowns and Methods.—These crowns are the invention of Dr. W. Storer How. There are two styles,—*four-pin crowns* for incisors, cuspids, and bicuspids, and porcelain *dovetail crowns* for bicuspids and molars. Each form embraces some novel features. Dr. How's methods, being general in application, are used in inserting other forms of crowns.

FIG. 129.

FIG. 136.

The following are Dr. How's descriptions and illustrations of his methods and crowns:—

FIG. 130.

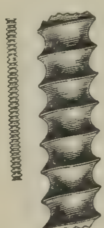


FIG. 131.

FIG. 132.

FIG. 133.

FIG. 134.

FIG. 135.

"**The Four-Pin Crown.**—The difficulties and uncertainties in mounting artificial tooth-crowns on roots, by either old or new methods, led me to a careful study of the problem, and resulted in a nearly simultaneous devising of several new forms of crowns and appliances for setting them, as well as a perfected method of performing the operation of fixing a peculiar screw-post (Fig. 130) in a root, and also a novel process of attaching the crown to the post. At present I will describe simply the four-pin crown (Fig. 131) and the successive steps to be taken in mounting it.

"1. When the root is in proper condition for mounting, measure the depth of the canal by means of the canal-plugger and its flexible gauge (Fig. 129), and fill the canal at and a short distance from the apex of the root, keeping the gauge at position to

show the full length of the canal and also the distance to which it has been filled.

"2. Cut off the root-crown with excising forceps and a round file, down to the gum-margin, and with barrel-bur No. 241 cut the labial part of the root fairly under the gum without wounding it.

"3. Set gauge on a Gates drill (Fig. 136) to one-half the gauged depth of the canal, and drill to that depth.

"4. Set the twist-drill in its chuck (Fig. 132) to project the

FIG. 137.

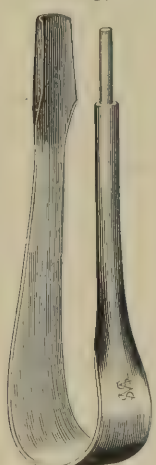


FIG. 138

FIG. 139.

FIG. 140.

FIG. 141.

same length as the Gates drill, and drill the root to exactly that depth.

"5. Enlarge the mouth of the canal one-sixteenth of an inch deep all around to near the margin of the root, as shown in Fig. 133, using square-end fissure-bur No. 59, and then with oval, No. 94, undercut a groove lingually and at the sides.

"6. If the rubber-dam is to be used for a gold or plastic backing, put it now over the root with Hunter's root-clamp, also over the adjacent teeth, and thoroughly dry the canal.

"7. Set the tap in its chuck (Fig. 134) a trifle less in length than the drill, oil it, and carefully tap the root to the gauged depth.

"8. Insert the post in its chuck (Fig. 135) to the exact gauge of the tap, and turn the thumb-screw down hard on the end of the post, then screw the post into the root, release the thumb-screw, unscrew the chuck a half-turn, bend the post until the chuck stands in center line with the adjoining teeth, and unscrew the chuck from the post.

"9. Slit the rubber back from adjacent teeth, tucking the flaps out of the way so that the occlusion may be tried, the post excised and ground off until the teeth close clear of the post.

"10. Try the crown on the post, and with disk grind the rib between the neck-pins until the crown is labially flush with the root-margin, using the disk dry and cutting a little at a time until exactly flush.

"11. Take the crown and place the mandrel (Fig. 137) between the pins just as the post is to be, and with the pliers (Fig. 138) bend the pins carefully over the mandrel, cutting off the pins if too long to be pinched in on the mandrel at the sides, observing that the pin nearest the cutting-edge is first to be bent (Fig. 139), and the opposite pin bent *below* it on the mandrel, and so with the others (Fig. 140).

"12. Slip the crown over the post, try occlusion, and with the post-chuck bend the post until the crown is properly aligned with the teeth, then with a stump corundum-wheel No. 3 grind the neck of the crown to a close labial fit with the root, fitting only the portion to be concealed by the gum, leaving narrow gaps at the sides to be filled by the backing between crown and root (Fig. 141).

"13. Grind cutting-edge for occlusion and relation to the other teeth, and be sure that the opposing tooth does not strike the crown, the post, or the pins.

"14. Fix the crown on the post by pinching the pins into the screw-threads in the post with the special pliers for that purpose.

"15. Finally, pack the backing of gold, or cement, or amalgam, or Wood's metal,* or—for temporary backing while treating abscess—gutta-percha, into all the crevices around the post and behind and under the pins, and between the crown and the

* Wood's metal suggested by Prof. J. Taft.

root; contour and finish thoroughly, so that no ledge or other imperfection can be found.

"Fig. 142 shows in vertical mid-section an incisor crown mounted on a root; the blackened portions of the backing

FIG. 142.

FIG. 143.

FIG. 144.

serving to define clearly the locking-hold of the backing on the screw-post, the crown-pins, and the root recess.

"Fig. 143 shows in perspective a cuspid crown ready to be slipped over its post, and also a cuspid crown ready for its post in the bicuspid root, which has its lingual cusp remaining; and

FIG. 145.

FIG. 146.

FIG. 147.

Fig. 144 shows these crowns on their posts awaiting the completing or contour-backing.

"When it is desired to contour the backing of a cuspid crown to form an inner cusp, or to adapt a cuspid or incisor crown for masticating uses, the pins may be twisted together over the mandrel, and again twisted tightly over the post, as in Fig. 145; but in some cases it may be better to bend the neck-pins, as in Fig. 146, instead of twisting them. In all cases the bent pins

are to be pinched quite hard over the mandrel and post, so that the serrations of the pliers will roughen the pins to prevent their being pulled through the backing, which should also be carefully condensed around the pins and post.

"When the root is much decayed, the bottom of the cone-shaped cavity may be drilled and tapped to the depth of a sixteenth of an inch, and the post, thus anchored, may be further secured by cement in the grooved walls of the cavity and around the post (Fig. 147).

"The screw-posts are made of crown-metal, an alloy devised for the purpose in order to obtain a stiff post that will permit

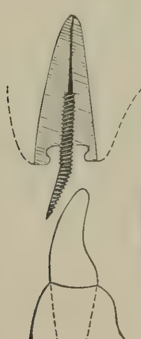


Fig. 148.

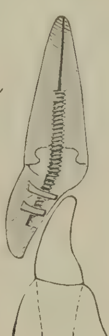


Fig. 149.

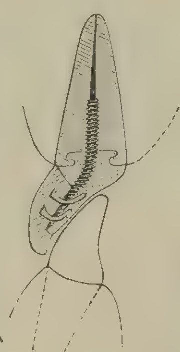


Fig. 150.

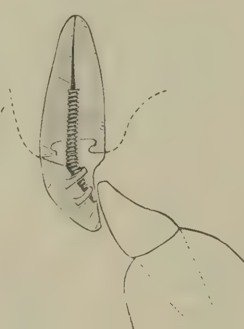


Fig. 151.

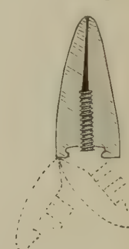


Fig. 152.

the cutting of the peculiar and extremely accurate thread formed upon it, and which will not amalgamate or be otherwise affected by any backing material that may be used. Of course, platinum or platinum alloyed with iridium may be employed for posts, but the crown metal is in every way superior.

"There are some cases of a class which has hitherto presented difficulties that may now be easily overcome by grinding the post flat on the crown side after it has been set and bent in the root (Fig. 148), so as to be clear of the occluding tooth; and then the crown-pins may be bent over the reduced post, the crown fitted and ground to clear the opposing tooth (Fig. 149), and the backing added in completion.

"A similar case, in which the opposing tooth and a proper

alignment require an oblique bending of the pins, is seen in Fig. 150, while the reverse arrangement of parts is shown in Fig. 151. The crown is thus seen to be adapted to a wide range of adjustments, because its point of contact with the root is at the labial portion of the neck, on which, as on a hinge, the crown may be swung out or in (Fig. 152, dotted lines), over an arc of at least sixty degrees, at any point of which it may be quickly and firmly fixed. The labio-cervical junction is made just under the gingival margin, and I usually interpose a thin layer of cement, amalgam, or gutta-percha, or a narrow ribbon or several large blocks of soft gold; the joint always to be made carefully smooth, and hid from view under the free margin of the gums."

The Porcelain Dovetail Tooth-Crown.—These crowns are

FIG. 153.

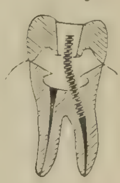
FIG. 154.

FIG. 155.

FIG. 156.

FIG. 157.

FIG. 158.



designed for the roots of bicuspids and molars only, and the process of mounting them may be very briefly described.

"Fig. 153 shows the roots of an inferior molar after the apical portions have been filled, the neck recessed, the canals drilled and tapped, and two How screw-posts firmly fixed therein, the ends of the posts having been pinched toward each other by means of a pair of pliers, so that they will go through the central opening in the crown (Fig. 154). This opening is of a dovetail form, as shown in cross-section by Fig. 155, where the crown is seen in place over the posts on the root. It is thus made obvious that the crown may be easily put on and off the root in the process of fitting the crown-neck to the root-neck, and also that, for occlusion, the crown may be ground low on any or all sides without destroying the dovetail function of the central cavity. When the fitting is completed, and the crown cut so short as to be $\frac{1}{32}$ of an inch distant from the occluding tooth,

amalgam is packed into the neck recess, around the posts, and thinly over the cervical margin of the root, the crown put in place, and, with thumb pressure, firmly seated. Then test the occlusion, and complete the operation by packing amalgam into the crown opening, which will permit the forcing of the amalgam in all directions, to insure a firm base for the crown and its secure dovetail attachment to the posts, as shown by Fig. 155.

"The bicuspid crown (Figs. 156 and 157) is similarly mounted, as may be seen in Fig. 158, cross-section; the same crown and root being shown in contour by Fig. 159. In some instances this bicuspid crown may, like the Foster crown, be secured by a headed screw, as shown in Fig. 160. The root having been drilled and tapped and recessed, and the crown properly fitted

FIG. 159.

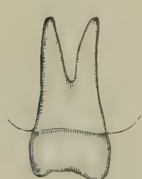


FIG. 160.

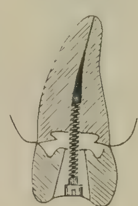


FIG. 161.

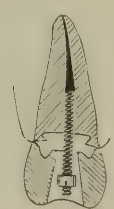
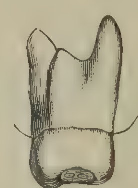


FIG. 162.



and articulated, the screw is put through the crown, amalgam packed in the crown-groove and around the screw, which is then inserted in the root, and the crown pressed hard into its place. The screw is then turned into the position shown in Fig. 160, thus compressing the amalgam or cement in both recess and groove, after which the screw-head may be covered with amalgam, cement, or gold, as desired.

"As a preferable mode, however, the screw-post may first be fixed in the root, the crown adjusted over the post, amalgam packed on the root and around the post, the crown seated firmly, more amalgam packed in the crown cavity around the post, and then a nut screwed on the post, as shown in Fig. 161. In all the sectional cuts cement, amalgam, or gutta-percha is to be understood as filling the cavities in the conjoined roots and crowns.

"Fig. 162 shows in contour a dovetailed crown mounted on a

superior molar root in the manner shown by Fig. 155. It is obvious that the crown of Fig. 155 might be ground quite down to the post-ends, and yet be firmly held by the dovetail sides of the central cavity."

The Gates Crown.—The Gates crown is quite similar to the Bonwill crown. It is usually attached to the root, however, by

FIG. 163.

a metallic screw manufactured for the purpose, such as is illustrated in Fig. 164, instead of the Bonwill pin. The screw is first inserted in the root and the amalgam packed around it. In nearly all roots, at a reasonable distance up the canal, a suitable place for fastening the end of the screw can be found. Too much force must not be applied in its insertion, as a root is easily split. In bicuspid and molar crowns nuts are used on the screws, which fit slots in the grinding-surface of the porcelain. They are screwed into the amalgam or cement, and covered with it in the process of cementation of the crown.

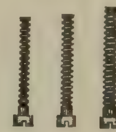
FIG. 164.

The Foster Crown.—The Foster crown also resembles the Bonwill, but has less concavity at the base. The crown is attached to the root by a headed screw (Fig. 166) or a screw with a nut, instead of the Bonwill pin.

The How screws and instruments (Fig 167) are best adapted for use with these crowns.

Fig. 165.

Fig. 166.



The Howland Crown.—This crown is attached like the How dovetail crown, with screws that are first inserted in the root. It is used mostly on bicuspid and molar roots, and consists of a hollow porcelain crown, with a cavity in the crown sufficiently large to admit the screws or pins (Fig. 168) and, when necessary, a small portion of the root.

Fig. 167.

Fig. 168.

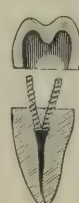


Fig. 169.

Fig. 170.

The method of setting this crown, as described by Dr. S. E. Howland, the inventor, is to trim the root even with the gum, with a stump file (a corundum stone or the Ottolengui root-facer on the dental engine, however, is more suitable); fit the crown to the root; enlarge the root-canal so that a threaded pin of proper size will pass in easily, partially fill the canal with zinc phosphate, and press the pin to its place with pliers. The crown should then be filled with zinc phosphate and pressed to its place, care being taken to hold it in position until the cement sets (Fig. 169). If any operator distrust the ability of zinc phosphate to make a perfect joint, a small quantity of silver amalgam or gutta-percha can be used to advantage.

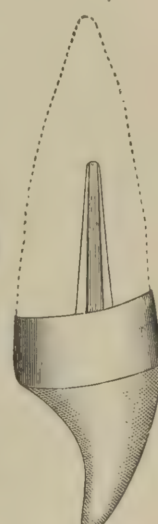
This crown is strong, and during its test of several years none have broken, so far as known. The mode of fastening is strong and simple, and when set, if a good joint has been made, none of the phosphate or other setting material is visible. It is a perfect imitation of the natural tooth (Fig. 170).

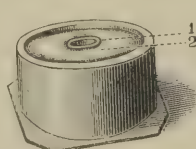
PORCELAIN CROWNS WITH GOLD COLLAR ATTACHMENT.

A very good combination for some cases, is to use a gold collar, either seamless or soldered, in combination with any of the porcelain crowns.

The root having been properly prepared to receive a collar, it is adjusted and adapted the same as for the Richmond crown (see page 224). The porcelain crown, the base of which should be fully as large as the end of the root, is then ground even with the cervical walls, and fitted into the collar, which should be trimmed and burnished to the form of the crown. Dr. Townsend's fusible metal die, used in the following manner, facilitates the application of a collar to a Logan crown (Fig. 171). Prepare the root-canal to receive the pin. Grind a suitable Logan crown to fit, and articulate it. Construct a band of No. 30 gold (for instructions see page 226), which should be wide enough to project beyond the end of the root $\frac{3}{32}$ of an inch. Cut a wooden peg about an inch long and taper one end of it to the general size and shape of the pin in the Logan crown. Place the band on the root, insert the peg in the canal, and fill up the band with Melotte's moldine, pressing it closely about the peg. Remove all together and, holding the die over the flame of an alcohol lamp to melt the fusible metal, place them altogether on the die, with the pin in the socket, and press down until the moldine rests on the surface of the molten metal. Then carefully chill the tooth; in cooling, the fusible metal takes a firm hold on the lower edge of the gold band, holding it securely in place during the remainder of the operation. Now remove the peg and the moldine, and with a wooden mallet drive the Logan crown into the band *until the porcelain rests upon the fusible metal.* Burnish the band smoothly about the crown. When it is perfectly adjusted to

FIG. 171.





1. Socket. 2. Fusible Metal.

the porcelain, melt the fusible metal to release the band and crown.

If the work has been carefully done, the crown will then be ready to be adjusted in the mouth.

Enough of the labial portion of the band should be trimmed

FIG. 172.

FIG. 173.

FIG. 174.

away to prevent too conspicuous exposure of the gold (Fig. 172).

This collar combination is available in very difficult cases, as, for instance, when a root is decayed upon one side beneath the gum margin, as seen in Fig. 173.

This operation, when completed, would appear in vertical

FIG. 175.

FIG. 176.

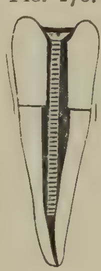
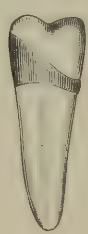


FIG. 177.



section like Fig. 174, and a view in perspective would resemble Fig. 175.

Dr. E. C. Kirk's Method, of combining the porcelain crowns with a band or collar, is shown in Figs. 176 and 177. Here the Foster crown is employed. First a collar is made and fitted to the root; it is cut narrow on the labial side, and left wide on the

lingual, so that it shall extend nearly to the cusp of the crown when finished (Fig. 177). The seamless gold collars are well suited for application to this style of crown.

The crown selected should have a somewhat greater circumference at the base than the collar, so that when ground down somewhat conically on its lingual and approximal surfaces, it can be tightly adjusted to the collar, which would be impossible, if a crown smaller than the collar is used. The screw is fitted so that it will hold the crown in proper relations with the root. It is then removed with the crown, the parts dried, and the root-canal filled with a slow-setting oxyphosphate cement. The crown is then pressed home, the surplus cement flowing through the opening in the porcelain and filling up any interstices around or between the band, the root, and the crown. The screw is then forced to position, and when the cement is set perfectly hard the head of the screw or the nut on it is notched to form a retaining-pit, and the countersink of the crown filled with gold.

Dr. C. S. W. Baldwin's Method is to cap the root and attach a Logan crown in the following manner:—

First, the root is shaped for the proper adaptation of the band. The band and cap are then made as directed for the Richmond crown on page 226. The edges are then trimmed to fit the festoon of the gum; a hole drilled from the inner side for the pin, leaving the raggedness made by drilling to catch in the cement. Place the cap on the root and fit the porcelain crown accurately to it in the desired occlusion and position. Fig. 178 shows a root, cap, and a Logan crown. A crown having the H-shaped pin, but square on the edge, like some of the early patterns of Logan or Bonwill crowns, would reduce the time of setting and give best results. Having polished the edges of the cap, the crown may be conveniently adjusted as follows: Place oxyphosphate cement in the countersunk portion of the porcelain, and in the canal only enough cement, of creamy consistency, to fill it, as the pressure required to force out the surplus under the edges of the cap destroys many nicely adjusted crowns, leaving bulging irritants instead of smooth supports. If proper attention has been given to fitting the

crown and root, all will come nicely to place; but in some cases of difficult adjustment it may be necessary to cement the crown to the cap before fastening the pin in the root (Fig. 179).

In most cases the gold band will be invisible and below the free margin of the gum. There are instances, where the anterior teeth are prominent, that it will be necessary to cut away the top of the cap in front, allowing the porcelain to come directly in contact with the root, the band going deeper than in ordinary cases, which prevents the appearance of gold (Fig. 180).

Dr. Bonwill's plan is to cap the tooth with a platinum or gold cap having a slot, into which the pin passes as it is slipped on the root (Fig. 181). The crown is then secured with amalgam in the usual way.

FIG. 178.

FIG. 179.

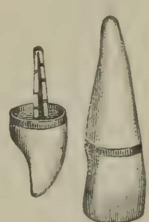


FIG. 180.

FIG. 181.

Dr. Sidney S. Stowell's Method is as follows: Make a closed cap, using the combination crown metal, and place it upon the root. The cap is then perforated and the root reamed for the dowels. The bite in wax is now taken, after which the cap is burnished into the countersunk end of the root (Fig. 183). The dowels of platinum and iridium wire are now set in their places, being allowed to project one-fourth of an inch so that they may adhere to the impression of plaster which is then taken. From this a cast is made of investing material; calcined marble-dust and plaster is preferable, though fine molding-sand will do. The dowels are now cut off even with the top of the cap (Fig. 184).

The tooth to be used may be a Logan or Brown crown, or a common countersunk tooth, but I would in most cases recommend the Logan crown. As the case in question is a bicuspid, I have selected for it a Logan crown. First, cut off the pin, and then the tooth is ground into position on the cap; grinding the stump of the pin and porcelain alike evenly and smoothly. The stump of the pin is now ground with a small wheel below the surface of the porcelain (Fig. 185). The tooth is invested (Fig. 186), and pure gold fused on to the platinum pin, and while in a fluid state it is with a wax spatula spatted down flat (Fig. 187). The gold is filed or ground down even with the porcelain, and at the palatal border the tooth is ground to bevel back until the gold is reached (Fig. 188). The tooth is now fastened in place on the cap with wax cement (Fig. 189),

FIG. 182.


FIG. 183.


FIG. 184.


FIG. 185.


FIG. 186.


FIG. 187.


FIG. 188.


FIG. 189.


the cast cut away, and the case invested in asbestos and plaster (Fig. 190). This is used because of the fiber of the asbestos, which prevents the separation of the crown and cap. The wax is removed with boiling water, or is burned out, the case thoroughly heated up, then a small clipping of thin platinum plate is crowded into the opening (see Fig. 190) caused by the grinding of the bevel on the crown. The clipping of platinum serves as a lead for the solder, which follows it down into the countersunk cap, around the ends of the dowels, and finally attaches itself to the pure gold already firmly attached to the stump of the platinum pin. When cool the case is removed from the investment, dressed and polished (Fig. 191). A sectional view of a like tooth (Fig. 192) shows the organization in detail.

Fig. 193 shows a central incisor root on which a Logan crown is used after this method. Fig. 194 shows how delicately an

operation of this kind may be performed upon an inferior central incisor, by the use of the countersunk tooth-crown, which is shown as it appears before gold has been melted in its cup around the pin; when the cup has been filled with gold, and after the crown has been ground and beveled. A countersunk molar crown is shown as likewise mounted on the roots of a superior left second molar (Fig. 195).

The cuts are made from photographs of prepared specimens, the natural roots of which vary in the several figures; and in the section (Fig. 192) the continuation of the pulp-canal does not appear, because obliterated in preparing the section.

The claims for this method of crown-work are as follows: The combination of an all-porcelain crown with a closed cap and

FIG. 190.

FIG. 191.

FIG. 192.

FIG. 193.

FIG. 194.

FIG. 195.

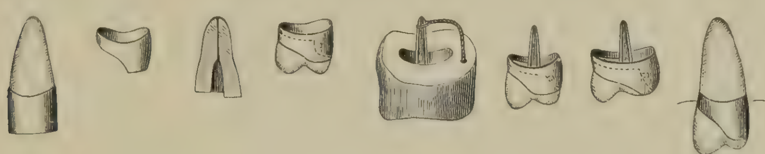
dowels; the adaptation of which crown and its final attachment to the root can be made perfect.

The dowels may be set at any angle that the direction of the root-canal may indicate, using one or more dowels as the case may require, and when the root has to be cut off much below the gum, and a collar cannot be placed, a platinum disk-floor on the root-end is the preferable plan. The well known and easily detected plate-tooth having a gold backing which renders the tooth dull in appearance is thus made obsolete, for this crown possesses the translucent appearance of the natural organ. Best of all, the glaring gold of which some so-called beautiful crowns are almost entirely composed is by this means superseded. We here refer to gold bicuspids and molars, more especially to the former; it was the unsightly appearance of these which first led us to try and improve on them.]

While recognizing the unquestioned value of the closed cap and dowel, I respectfully present a supplemental method which results in a crown possessing all the merits of the former with additional embodiment of strength, beauty, and practicability.

Dr. Shulze's Method.—Another method of crowning, by using a plain rubber porcelain tooth in combination with a gold collar is that described by Dr. Wm. H. Shulze, Atchison, Kansas. The doctor says: My mode of utilizing the plain rubber porcelain tooth for a bicuspid crown will be found to be both simple and practical. After preparing a tooth-root as for an all-gold crown by fitting over the root-neck a gold collar of the proper width, as in Fig. 196, remove and cut away the front of the collar (Fig. 197). Bevel the labial edge of the root so that the tooth can set well into the collar (Fig. 198). Replace the collar on the root,

FIG. 196. FIG. 197. FIG. 198. FIG. 199. FIG. 200. FIG. 201. FIG. 202. FIG. 203.



dry out, and place a little softened wax on the end of the root. Select a suitable plain rubber tooth, nip off the heads of the pins, grind so that it will enter the collar, adjust, and articulate, pressing the tooth against the wax. Carefully remove the collar and tooth (Fig. 199). Invest in plaster and asbestos fiber (Fig. 200). Fit a thin piece of platinum into the collar, burnishing it down on the tooth, and bending it down to the pins. If it is desired to use a post, remove and punch the platinum plate at the proper place, and solder in a post; replace within the collar, and secure with a piece of binding-wire imbedded in the investment (Fig. 200). A little 18 k. solder will join together the collar, platinum plate, and tooth-pins (Fig. 201). If there are any places where the collar does not fit the tooth closely, pack in gold foil before soldering. If the inner cusp does not fill the collar, or it needs lengthening for occluding purposes, get the desired shape with wax when fitting the tooth. Remove the

wax after investment, pack in gold foil pellets, and add enough 20 k. solder to flow through it, and the desired addition will appear as in Fig. 202. The completed crown, mounted as usual with cement, is shown in Fig. 203.

The advantages of this method are its simplicity, ease of adaptation and articulation, the short time required to fit and make the crown, its strength, security, and natural appearance, and the convenience of using a plain rubber or saddle-back tooth.

FERRULE OR COLLAR CROWNS.

The Richmond Crown.—This crown was originally brought to the notice of the profession by Dr. C. M. Richmond, of New York. Numerous modifications have been made, however, which enhance its value. The process of constructing the improved crown is as follows:—

1. The root must be trimmed down to about the gum-line, except the labial portion, which should be cut nearly a sixteenth of an inch below the gum margin. For this purpose, corundum stones or the Ottolengui root-facers are employed, as shown in the preparation of roots for the Logan Crown. (See pages 190, 192.)

Fig. 204.

2. The ring of enamel remaining upon the root should be carefully and thoroughly removed, (see Fig. 204) making the sides of the root parallel, so that the band, when applied may *fit closely its entire width.* If this is not done, the band, even if a narrow one, instead of fitting closely will form a pocket beneath the gum margin, and will, in consequence of its irritating effect upon the surrounding tissues, cause more or less inflammation and possibly the loss of the root.

Numerous instruments have been devised for the removal of this enamel; among the most efficient are those invented by Dr. Calvin S. Case and Dr. Geo. M. Weirich. Fig. 205 illustrates Dr. Case's enamel cleavers. These are so shaped that they can be partially rotated under the margin of the gum, presenting a sharp point toward portions of the enamel that will not easily clean off, with a view to fracturing it as the diamond cuts glass, breaking it up into small pieces which can readily

be detached and the sides straightened and smoothed by the

FIG. 205.

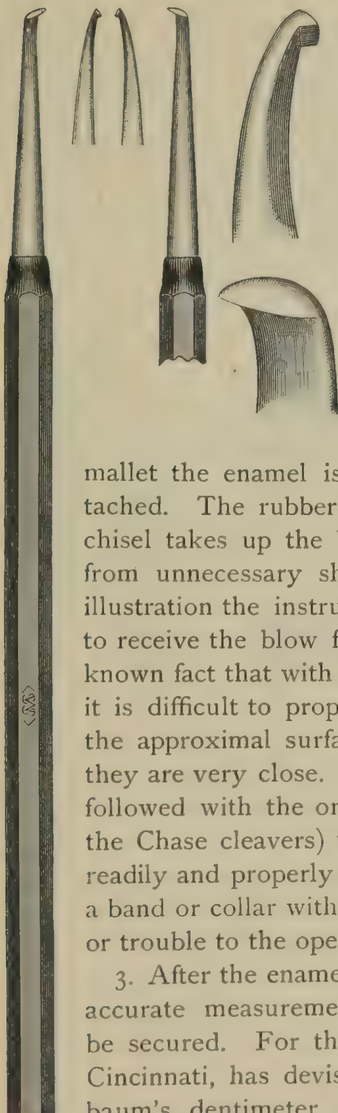
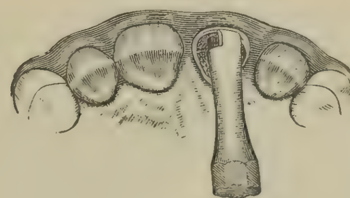
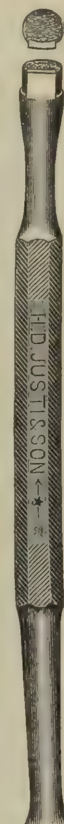


FIG. 206.





broad blade. The peculiarities of shape are shown in the enlarged cuts.

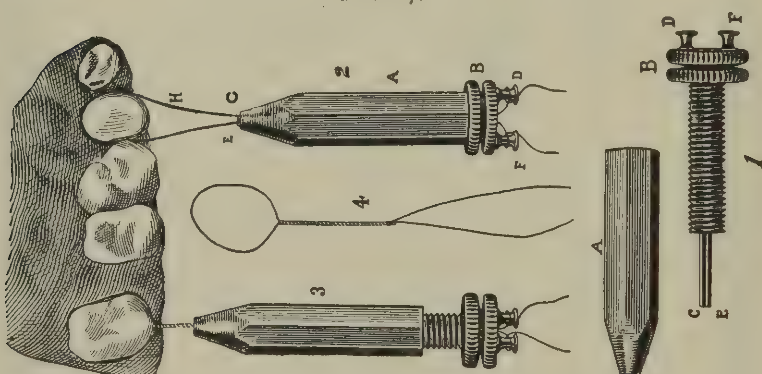
The Weirich cleaver or chisel is shown in Fig. 206. With this instrument and a few gentle blows from the mallet the enamel is readily broken up and detached. The rubber cushion in the center of the chisel takes up the blow, thus relieving the root from unnecessary shock. In the accompanying illustration the instrument is shown in place ready to receive the blow from the mallet. It is a well-known fact that with most of the appliances on sale it is difficult to properly remove the enamel from the approximal surfaces of roots, especially where they are very close. With this instrument (to be followed with the ordinary cervical-wall chisel or the Chase cleavers) the root upon all sides can be readily and properly prepared for the reception of a band or collar with very little discomfort to the patient or trouble to the operator.

3. After the enamel has been thoroughly removed, an accurate measurement of the neck of the root should be secured. For this purpose Dr. A. I. F. Buxbaum, of Cincinnati, has devised an instrument known as Buxbaum's dentimeter, with which the work can be very satisfactorily performed. It is illustrated in Fig. 207. It is very simple to adjust and operate, and has the advantage

over other instruments of this kind, that, as you do not have to twist the entire instrument, the wire does not incline to slip off the root or lacerate the gum.

Dr. Buxbaum gives instructions for using his dentimeter as follows: Pass one end of a soft wire through tube at C, as shown in Fig. 2 of accompanying illustration, and wrap once around knob D. Pass the other end of wire through tube at E, as shown in Fig. 2, and wrap around knob F. Place the loop H around the tooth or root. While unscrewing the screw, by holding milled nut B between the thumb and forefinger of

FIG. 207.



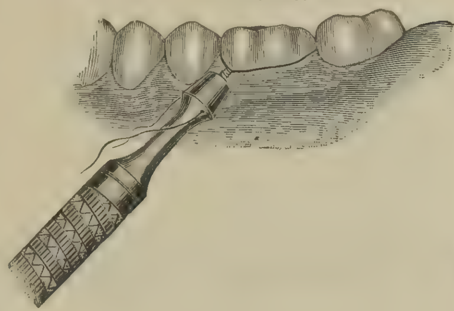
right hand, you must make *constant traction on loop* around the tooth by gently pulling on barrel A, held between thumb and finger of left hand, this will give a perfect twist, as shown in Fig. 3. Unfasten ends of wire from the knobs D and F and withdraw from dentimeter. The result is shown in Fig. 4.

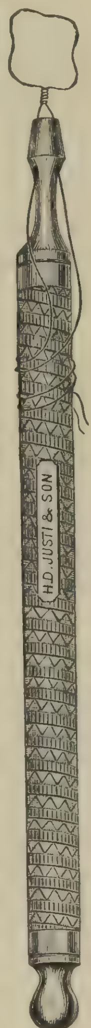
Other and simpler instruments for taking measurements of teeth or roots have been devised, notably the one by Dr. Geo. M. Weirich, of Philadelphia, which is shown in Fig. 208.

4. In order to transfer this measurement accurately to the banding material, cut the wire loop in the center and spread the ends in opposite directions, as shown in Fig. 209. It is then laid on the piece of gold to be used for the band (which should be 22 k. and about 30 gauge); this should be cut the *exact length of the wire*, and about an eighth of an inch in width, unless for

special reasons it is necessary to have it wider. This small strip of gold should now be annealed over a lamp or Bunsen burner, then with round-nosed pliers it should be brought into a circular form, and with the fingers the ends should be carefully pressed by each other. This will form a slight kink in the band, so that the ends, if now gently drawn apart and let go, will spring accurately together ready for soldering.

FIG. 208.





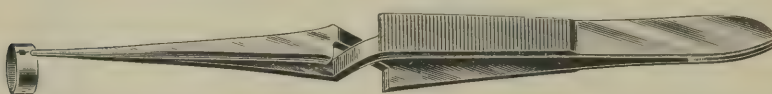
5. In soldering the band, a corner of the two edges should be grasped with the soldering pliers, the joint should be slightly coated with borax, and a small piece of 20 k. solder placed over it, *on the outside of the band* (see Fig. 210). It should then be held in the flame of a Bunsen burner until the solder flows, at which time it should be *instantly removed.* With a little experience and care in soldering in this way (over a Bunsen burner), it can be done more conveniently, in less time, and with much less danger of burning the band, than with the blowpipe.

FIG. 209.

6. The band is now ready to be fitted or adjusted to the root. If the end of the root is not round, as is usually the case, the sides of the band can be flattened or otherwise shaped with slight pressure from the thumb and finger or with suitable pliers. The upper border should then be trimmed to conform to the shape of the process or the line of the gum-attachment; in many cases, unless the band is greatly depressed or cut out on the sides, it will be found that

the gum will be detached from the sides of the root, and that the process will be reached before the root is covered high enough on the labial and palatal surfaces. Place the band thus shaped upon the root, and if the measurement and each progressive stage have been accurately performed, it will be found to fit perfectly. Now press or drive it up carefully, until the point of attachment between the soft tissues and the root are

FIG. 210.



reached (about one-sixteenth of an inch beyond the gum margin), which is shown by the slight whitening of the gum. When this is very marked upon any side, the band should be removed and relieved by cutting it away at that point, and then readjusted. A corundum-wheel is now gently passed over the labial portion of the lower edge of the band, to level it with the face of the root and to render the band invisible when the crown is finished. In doing this the wheel used should be revolved *toward the root*, so it will not irritate the soft tissues, as it would were the force applied in the opposite direction,—and at the same time it will turn the feather-edge of metal over the end of the root.

7. The base plate is more easily and quickly formed. Cut a piece of gold (32 to 34 gauge) of suitable length and width, anneal, and then press it against the lower edge of the band with the fingers until it is nicely adapted; secure it in this position for soldering by three or four strands of wire, as shown in Fig. 211. Now paint the joint with borax dissolved in water, lay a small piece of 20 k. solder against the back or palatal portion of the band, *on the outside*, and hold it in the flame of a Bunsen burner until the solder flows, which will be seen to run entirely around the band, uniting it with the base plate at every point. The surplus of the base plate material should, with shears and corundum stone, be trimmed off flush with the band, the two now forming a complete cap for the face and sides of the root.

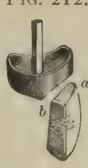
FIG. 211.

8. The next step is the preparation and adjustment of a pin through the cap into the root canal. The canal should be enlarged toward *the palatal* side of the root; this will give more room when we come to grind the tooth, and at the same time secure the greatest attainable strength when the crown is completed.

The base plate of the cap is perforated at a point directly over the opening into the canal. This may be done either with a bur on the dental engine or with the plate punch. A pin of platinum wire, number 16 or 17, standard gauge, should now be slightly tapered at the end and passed through the aperture made in the cap and up into the root canal. The end of the pin projecting below the cap may be marked, withdrawn, and bent at a right angle, so that it will point away from the tooth, that is, toward the palatal surface; it may then be waxed in, invested, and soldered with the tooth, or, invested and soldered at this stage, and the surplus of pin and solder brought down flush with a file or stone.

9. The cap and pin should be readjusted to the root. A plain-plate tooth,* of suitable form and color, is now ground and fitted to the cap. The labio-cervical edge of the tooth (*a*, Fig. 212), should be so ground that it will be flush with the edge of the band and meet the margin of the gum. It should also be ground out at the center of the base (*b*), so as to form a slight space just over the base of the pin.

FIG. 212.



The tooth is then backed with either thin platinum or gold-plate (gold will give a slight yellow shade to the tooth while platinum will give a bluish tint). The upper edge of the backing, brought down thin with a file or stone, should extend as far as possible under and between the tooth

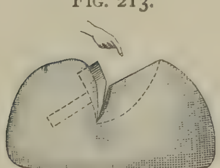
* Many writers advise using cross-pin teeth; it is self-evident, however, that in this work straight-pin teeth should be employed and the cross-pins avoided wherever possible, for the following reasons: (1) The position of the pins weakens the body of the tooth. (2) Their position makes the strain upon the tooth greater, as it gives increased leverage between the pins and the cutting edge. (3) There is more liability of cracking the teeth in soldering, on account of so much metal being brought at one point.

and the cap, so that the solder will more readily flow in and fill what space there may be. The incisive edge of the backing should also be brought slightly over the edge of the porcelain (though it is not so shown in the accompanying illustrations), this portion of the tooth being previously beveled with a fine corundum stone. In this, the possibility of breaking the tooth from the force of mastication is much diminished.

10. A perfect joint and the proper length and angle of the tooth having been secured, the pieces, that is, the tooth, cap, and pin, should now be thoroughly dried and then held together in the proper relationship, and secured in this position by running warm adhesive (resin) wax over the palatal portion of the tooth, attaching the backing to the cap. It should then, before the wax gets very hard, be carefully carried to position upon the root, when any correction in the position of the tooth can readily be made. Now apply a little cold water from the syringe or on a pledget of cotton; this will harden the wax, so that the crown may be removed without changing the position of the tooth upon the cap. It will then be ready to be invested for soldering.

A most suitable investment for crown work is marble-dust and plaster, equal parts, with a small quantity of fine asbestos fiber thoroughly incorporated. After the investment has thoroughly set, the wax may be removed and the surface of the backing and cap cleansed by directing upon it a small stream of boiling water. The investment should be cut away so as to expose the sides of the backing and the lower border of the band, as illustrated in Fig. 213, but every portion of the porcelain should be protected. The case should then be at first gently heated up, to drive off the moisture, then transferred to the soldering block, when, with the blowpipe, more heat should be applied, continuously at first, until the investment and tooth are thoroughly and evenly heated throughout. Gold solder, 18 k., is then cut in small pieces and placed, with a little borax, over the aperture between the backing of the tooth and the cap. The investment being now uniformly heated, the flame from the blowpipe should be directed upon the

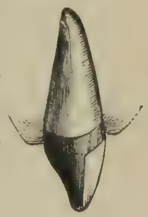
FIG. 213.



solder, mostly in the direction indicated in Fig. 213, when, if the entire case has been previously brought to a red heat, the solder will readily melt and flow between the tooth and cap. Additional solder should now be added and melted until the proper contour of the tooth is insured.

The tooth and investment should then be placed in and covered with sand, plaster, or some other suitable substance to keep the heat from radiating too rapidly and thus cracking the tooth. It should be left so covered until it is thoroughly cool. We might add here, that it is well to direct the flame from the blowpipe into the sand or other material for a moment before placing the tooth in. After the tooth is thoroughly cool, the investment may be broken away, and all oxidation and borax removed by placing it for a few minutes in the acid bath. The crown is then ready to be finished and polished. The shaping of the solder can best be done with corundum stones, followed with hard-rubber disks, and then fine sand-paper or cuttlefish disks, while the polishing is accomplished with brush and buff-wheels, pumice stone, whiting, and rouge. The completed crown in position is shown in Fig. 214.

FIG. 214.



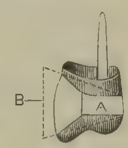
The Richmond Method Applied to Bicuspid Roots.—The capping of the root is similar to that already described; the crown will have greater strength, however, if a portion of the palatal section of the natural crown, when strong enough, is retained, and the band made deep enough to cover it. One pin is all that is usually required, and where there are two distinct canals, the palatal should be used to receive the pin; thus greater strength is secured at the point where it is most needed, and the pin is so located that it will not interfere with the grinding and adjusting of the tooth. The cap and pin being in position, a suitable cuspid tooth or bicuspid facing is then ground, backed, and adjusted to represent the labial aspect, and then properly secured to the cap with adhesive wax. The tooth, cap, and pin are then carefully removed, invested, and soldered; after which they are again placed upon the root, and the occluding edge of the tooth is ground clear of the antagonizing teeth at about the angle shown at A, Fig. 215.

From a suitable die or die-plate (see page 180, *et seq.*) the cusps or occluding surface of the tooth is swaged from 22 k. gold plate. These cusps should then be filled in with 18 or 20 k. plate or solder. This is done by cutting the gold into small pieces, and placing them, with a little borax, in the depressions of the cusps, all of which is held over a Bunsen burner until the small pieces are melted, when they will flow into these depressions and fill them level full. The surplus is trimmed away, the cusps ground and fitted to the edge of the porcelain front, in position to secure proper occlusion (Fig. 216), and secured with wax as shown at A.

FIG. 215.

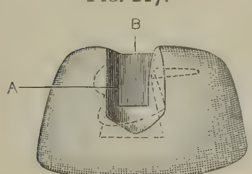
A piece of thin, pure gold plate or mica is then adjusted on each side of the crown (B, Fig. 216), the surfaces of which, if dry and slightly warm, will be held in position temporarily by pressing them gently against the side of the wax. This is all now invested together (Fig. 217).

FIG. 216.



The long ends of these side pieces, after being invested, hold them in position, as the investment should be cut away so as to expose the sides of the crown as shown at A, Fig. 217. In the process of soldering, after the case has been properly heated, the small pieces of solder and borax are placed in the aperture formed by these sides of gold or mica (the place formerly filled with wax), and the flame from the blowpipe directed cautiously against these exposed sides (A). The solder will then flow, uniting the several parts, when more should be added until the proper contour with perfect continuity of structure is secured. The crown can be made without the gold or mica sides if great care is exercised in flowing the solder. There will be more surplus solder, however, to be finished off.

FIG. 217.



In finishing, the solder is brought to the contour of a bicuspid tooth with corundum stones and sand-paper disks, when it is ready for the polishing process. The finished crown is represented in place upon the root in Fig. 218.

There are other methods practised, and though some of them may not be as artistic as the one just described, they are much simpler and quicker. For instance, the palatal cusp may be built up with several pieces of gold plate—previously melted into the form of balls and flattened out with a hammer. The backing is brought down and closely burnished over the cutting edge of the tooth, which is then waxed in position, tried in the mouth, and invested, and when ready to be soldered, these flattened pieces of gold are laid in position, united and filled in with 18 k. solder, which is also brought over the backing to the tip of the tooth. This plate and solder are afterwards brought to the proper shape and contour with the stones and disks.

FIG. 218.

Then, again, the palatal portion of the band is extended down so as to nearly touch the antagonizing tooth. This leaves only a comparatively small space to be filled in with solder, which is afterwards trimmed and finished to the form of the crown.

Or, a method that the writer often employs, is to back the tooth, grind off or bevel the occluding surface, and then joint and adjust the prepared gold cusps; wax them in position, invest, and flow in sufficient 20 k. solder to hold them securely in position, after which the tooth may be ground, adjusted, and soldered to the cap, as has been directed. One advantage of this method is, that different forms and shades of bicuspid facings may be so prepared—with gold occluding surfaces—and kept in stock; and again, in the latter three methods, as may be seen, it is only necessary to invest the cap once after adjusting the tooth.

Dr. Litch's Method.—The method of Professor Wilbur F. Litch for forming collar crowns was first published in the *Dental Cosmos*: (Vol. xxv, p. 449), and was afterwards revised and reproduced in the *American System of Dentistry*. In this Prof. Litch describes his method as follows:—

"The processes to be described reduces destruction of tooth substance to the minimum. Instead of cutting the palatine wall of the tooth down to the gum-margin, the greater portion of it is carefully conserved, its presence, while not indispensable to a

successful result, being in the highest degree desirable. How much of this portion of the tooth can be retained will depend upon the nature of the occlusion.

"In Fig. 219 the dotted line from C to D represents the point to which the tooth is cut away in the older methods of 'pivoting:' the dotted line from A to B, the line of abscission practised by the writer.

FIG. 219.

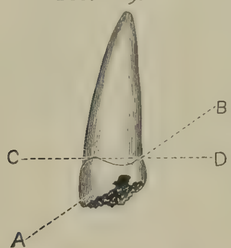


FIG. 220.

"As will be seen by reference to Fig. 220, the face of the tooth thus prepared presents a gradual slope from the palatal surface to the labio-cervical margin. At the latter margin the root should be cut down with suitable instruments to a point a little beneath the edge of the gum, in order that the porcelain tooth in front may pass up under the gum-margin and the joint between the tooth and root be concealed. At this point tooth substance may be sacrificed, as it does not materially diminish the strength of the root.

"The several parts employed in making the collar crown are a plain plate porcelain tooth or facing, a platinum-iridium retaining-pin, and a backing, base-plate, and collar made either of platinum, pure gold, or twenty-two-carat gold, either metal being made in thickness about No. 30 American gauge. When platinum is used coin gold or twenty-carat gold, alloyed with copper or silver only, should be employed as a solder and covering. Twenty-carat gold may be used as a solder when pure gold is employed, while eighteen-carat gold will solder the twenty-two-carat plate.

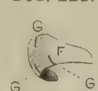
"In shaping the pulp-canal for the reception of the retaining-pin care should be taken not to weaken the root by an unnecessary enlargement of the caliber of the canal. The platinum-iridium pin need not be more than No. 14 American gauge in thickness at its point of greatest diameter, near the free surface of the root, where all the strain, if any, falls; from this point it should be made a gentle taper corresponding to the natural shape of the space it is to occupy. Half an inch in length is ample; even less will serve.

"The retaining-pin being shaped and adjusted in the root, care being taken to leave an excess in length at the free end for convenience in subsequent manipulations, the next step in the process is the making of the base-plate and its attachment to the pin. A strip of platinum or gold of suitable size is pressed upon the face of the root with broad-pointed, serrated instruments until it is in close adaptation to the surface at every point. This base-plate is allowed to *project beyond* and *overhang* the palatine portion of the root, but should not come quite to the labial edge.

"Adaptation being secured, an opening is made in the base-plate where it covers the pulp-canal, through which opening the retaining-pin may be pressed up into position in the root. Pin and base-plate are then removed from the mouth, dried, and cemented with a brittle resinous cement, and then, while the cement is still plastic and yielding from heat, placed again in position in and upon the tooth, and perfect adaptation secured. While still in position in the mouth, throw upon the cement a stream of very cold water, so that it may be made brittle and incapable of bending. Then remove from the mouth and invest in a mixture of equal parts of plaster and pulverized marble, with enough water to make a thick paste. After the investment has set solder the retaining-pin and the base-plate together.

"To make the collar, a somewhat crescent-shaped piece of platinum or gold of suitable size is prepared and pressed into shape upon the palatine and palato-proximal face of the tooth; little slits may be cut in the collar with a delicate pair of scissors, to make easier this adaptation. Care should be taken not to push the collar up under the gum at any point, provided the palatine wall of the tooth which had been allowed to remain standing is at all ample in height—say one-tenth of an inch; if less than this the collar may pass under the gum for a short distance, as will be shown subsequently. In the average case this collar will not quite one-half encircle the tooth.

FIG. 221.



Shape of Collar.

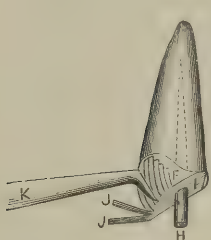
"Fig. 221 shows the collar curved to the outline of the gum-margin and shaped to the contour of the palato-proximal wall

of the tooth. At G are the slits cut in the platinum to allow overlapping in shaping to contour.

"In order to strengthen the collar and facilitate its attachment to the base-plate cut a series of slits in that portion of the base-plate which has been made to project beyond the palatine wall of the tooth, and the base-plate, with its now attached pin, being placed with the collar in position in and upon the tooth, the little strips of metal into which the overhanging edge of the base-plate has been cut are pressed, one after the other, down upon the collar and carefully molded to its surface, so that the collar will no longer consist of a single thickness of metal, but will be reinforced by these additional thicknesses of base-plate thus pressed upon it.

"Fig. 222 shows this quite perfectly: H is the free end of the retaining-pin, which is to be cut off when the porcelain tooth is mounted. I is the base-plate, with its overhanging palatine margin cut into strips, J, which are being pressed down upon the collar, F, by the broad-surfaced and serrated instrument, K. This being accomplished, remove the several pieces from the mouth, carefully cement the collar in its proper position relative to the base-plate, which will now form a sort of matrix for it, again place in the mouth, readjust, harden the cement, remove from the mouth, invest as before, and solder the collar and base-plate together, using a considerable excess of solder for covering, so that the collar may be still further strengthened and its surface be made uniform.

FIG. 222.



Pressing the Base-plate over the Collar.

"In cementing the collar to the base-plate one precaution is imperative—namely, not to allow a film of cement to get between the collar and the tooth. If this is done and the investment poured in upon this film of cement, the latter will immediately burn out as soon as heat is applied, leaving a space between the collar and the investment into which the gold solder will flow, and thus interfere with that perfect adaptation of the appliance to the tooth which is necessary to a successful result.

"The mounting of the facing, next demands attention. As

already stated, a plain-plate porcelain tooth is used. This must have what are technically known as cross-pins; that is, pins placed at right angles with the long axis of the tooth. They must also be placed well up toward the cutting edge. If they are too near the neck they will inevitably be cut out in fitting the tooth to the slope of the base-plate on which it must be mounted.

"Fig. 223 shows the form of the facing and indicates the slope given it in fitting. The fitting process does not differ from that ordinarily employed with porcelain teeth; an impression may be taken and the work done on a cast, or the facing may be fitted to the mouth. In either case it is in the mouth that the finer and final adjustments as to height, contour, alignment, etc., must be perfected.

Fig. 223.

Shape of Porcelain Facing.

"This being done and the facing backed, tooth and base-plate are cemented together, restored to the mouth, finally adjusted, removed, and soldered as before, as much gold being flowed into the angle between the backing and the base-plate as occlusion will permit.

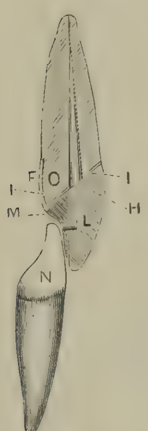
"This artificial crown, being properly finished and cemented into position in and upon the tooth, makes what the writer, from several years' experience in its use in a large number of cases, has found to be an appliance which will remain for an indefinite period without the slightest deviation from position and alignment, and which in many respects is almost as strong as the natural tooth, because its point of greatest resistance to pressure is placed where Nature anchors her enamel walls—namely, upon the *outside* and not upon the inside of the walls of dentine; so that in the act of occlusion the force applied by the lower incisors as they come up in position *inside* the upper incisors falls upon the *whole* thickness of the root *through the collar*, and not upon less than half its thickness through a centrally-anchored pin—a pin, too, prolonged into a lever of enormous power by its attachment to the porcelain tooth.

"In this respect there is a manifest weakness in all methods of mounting artificial crowns which depend for their stability solely upon the central pin. Ultimate failure through splitting

of the root is the frequent result, and the larger and stronger and more deeply anchored the pin the more certain this result, because a large pin necessitates a large opening for its reception, and a corresponding weakening of the root, upon which the strain must ultimately fall: the lever is strengthened and the point of resistance weakened.

"The only safety for the usual form of 'pivot-tooth' is, either that the occlusion shall be slight, the root very strong, or the 'pivot' very flexible or elastic. This elasticity of the old hickory 'pivot' was one of its chief excellences: roots were much less likely to split than with a rigid, unyielding metallic pin. In cuspids or incisors, however, metallic pins, unless enormously large, or thickly packed around the amalgam, will very often bend outward, thus allowing a slight displacement forward of the artificial crown, and to that extent relieving the root from strain.

Fig. 224.



Sectional view of collar-crown in position, the lower incisor in occlusion.

"Fig. 224 gives a sectional view of the collar-crown in position, the lower incisor being in occlusion. L is the porcelain facing. H is the pin attached to I, the base-plate. M is the backing and solder. N is the lower incisor, and F the collar. It is clearly evident that here the force of occlusion falls upon the palatine wall of the natural tooth at O through the collar F, and not upon the pin at the point of its attachment to the base-plate H, and through the pin upon the thin outer shell of the root.

"In cases frequently met with, where the entire crown of the tooth has been removed, the collar, as before described, can be adapted to the palatine face of the root, provided the latter be not decayed away up to the alveolar margin. Usually, however, there is a considerable space between the free edge of the root and the alveolus, and here, running up to the alveolus, the collar must be placed.

"The dotted line E in Fig. 220 indicates a collar so placed. All the steps in the process are essentially the same as before described. Adapting the collar to the surface of the root be-

neath the gum is somewhat painful, but not excessively so, and in the wearing the irritation caused by its presence is very slight and transient in character, assuming, of course, that care has been taken to leave upon it a smooth, thin, and well-polished edge.

"The objection may be urged that this form of crown resists pressure only in one direction, from within outward, and does not provide for lateral pressure or pressure from the front. As a rule, the latter can occur with any force only as the result of accident, while if the crowned tooth is in normal relation with its fellows, and the artificial crown be closely fitted between them, they will fully sustain lateral force.

"Where such lateral support is wanting through isolation of the tooth, the collar must be extended into a ring or ferrule completely encircling and grasping the root, and thus affording support on all sides. The ring, however, is more troublesome to make and more painful to apply, and generally shows a line of gold in front. In the average case the simple collar gives all requisite strength.

"In mounting crowns upon bicuspid and molar roots, however, the ferrule principle is often essential to stability; especially is this true of lower bicuspids and molars; as here the forces applied in mastication are as erratic in direction as they are powerful in character, and the root must be guarded at every point against their violence.

"In fixing in position the artificial crowns just described, the writer prefers to use a gutta-percha cement adhesive in character, which will not strip from the pin when the crown is forced into position.

"The apical foramen is closed, the pulp-canal grooved and thoroughly dried, the central pin is barbed, and the pin and inside of the collar and under surface of the base-plate are thickly coated with the gutta-percha; the entire appliance is then heated to a temperature sufficient to thoroughly soften the gutta-percha, and firmly pressed up into position: the excess of gutta-percha will ooze out at all free margins, and may be subsequently removed with suitable instruments.

"A good gutta-percha cement will hold firmly in a great majority of cases, but when, as in a small lateral incisor, the retain-

ing-pin is necessarily small and short and the collar not as ample as could be desired, an oxyphosphate cement, mixed thin, will be found to give greater stability. When this cement is used, however, it will be found very difficult to detach the artificial crown from the root, should it for any reason become necessary to do so; whereas a little heat will quickly soften a gutta-percha packing and permit the entire appliance to be withdrawn without difficulty."

As a modification of the manner of constructing the collar, Dr. Theodore F. Chupein contributes the following to the *Dental Cosmos* :—

"After the root-face has been dressed down as shown in Fig. 220, a piece of pure gold plate of No. 30 gauge is cut as shown in

FIG. 225.

FIG. 226.

FIG. 227.

FIG. 228.

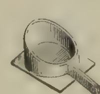


FIG. 229.

FIG. 230.

Fig. 225. This is bent around the root, as shown in Fig. 226, the wide part resting against its palatal aspect, while the ends are seized with a pair of narrow-beaked, flat-nosed pliers at the labial aspect. While thus held, the band may be burnished to fit accurately against the approximal and palatal parts of the root. This done, it is removed and the ends soldered together, as shown in Fig. 227. This band is then replaced on the root, and, as it hugs the root snugly, any of the edges which may be higher than the face of the root may be ground down even with a corundum stump-wheel. It is again removed from the root and laid on a piece of pure gold plate of the same thickness, to which it is soldered, as in Fig. 228. The overhanging edges of the plate, as soldered to the collar, are now dressed down even with the collar, and the forward part of the collar filed or ground away from the plate, as shown in Fig. 229. A hole is now

drilled or punched through the face-plate to receive the dowel, which passes through it into the root. The under part of the face-plate at the hole should be well countersunk, so that the solder that binds the dowel to the face-plate may creep through and hold the dowel on its under surface. The face-plate and collar, as shown at Fig. 229, are placed on the root and burnished down to fit accurately at all points. A slight smearing of cement is placed over the dowel-hole, so as to fill the countersink, and the dowel passed through and secured to the face-plate with more cement. Before this hardens it is placed on the root in its proper position, after which the cement is chilled by a stream of cold water, when it is removed, invested, and soldered. Fig. 230 shows the collar, face-plate, and dowel complete. This being accomplished, the face-plate is slightly reduced on its labial aspect, so as to expose the root against which the porcelain facing is to rest. The protruding part of the dowel is now cut off level with the face-plate, and the porcelain tooth fitted to it. This part of the operation does not differ from that indicated by Prof. Litch, and therefore need not be repeated here.

"The operation as set forth consumes much less time, is less tedious, does not demand the nice manipulative ability of the other, and is more certain in its results."

Dr. Knapp's Process.—No individual method has, perhaps more immediately and generally commanded the approval and commendation of expert and discriminating operators than the one brought to the notice of the profession by Dr. J. Rollo Knapp, of New Orleans, La. Omitting some judicious and pertinent general reflections on the subject (see *Dental Cosmos*, of Feb., 1887), all that relates to practical details in his methods of procedure is here reproduced.

"The collar being removed, its gingival border must be carefully filed so as to adjust it exactly to the various inequalities existing in the borders of the alveolar process and its investing gum. The other border should then be evenly filed down so as to reduce the collar to the requisite narrowness. A piece of pure gold plate, gauge thirty-four, is now to be soldered upon this latter border so as to convert the collar into a cap for the root. This cap must have pierced in it such an aperture as

will conform to the configuration of the pin or dowel best suited to the particular case in hand. Cap and pin waxed together, should then be tried in the mouth, carefully removed, invested in calcined marble-dust and plaster, and soldered. Being again placed upon the root, an impression of it should be taken, as well as of the two approximal teeth."

A set of small trays especially made for the purpose will be

FIG. 231.

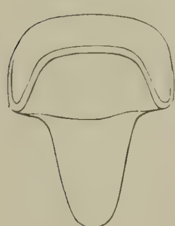


FIG. 232.

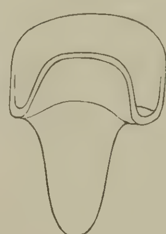


FIG. 233.

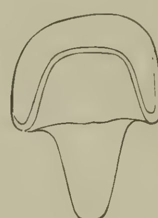


FIG. 234.

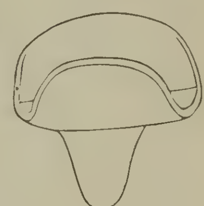


FIG. 235.

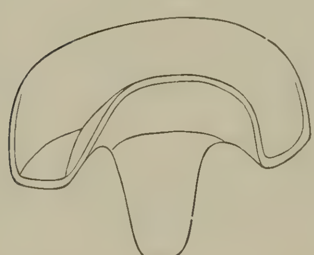


FIG. 236.

found very convenient for taking impressions for crown-work, Figs. 231 to 237. Plaster or modeling composition can be used in doing this. Upon its being ascertained that the cap, with pin attached, is in its proper position in the impression, a plaster cast can be obtained, which, with a cast of the occluding teeth, should be placed in an articulator.

While the writer believes it to be the most accurate, when making single crowns, to grind and adjust the tooth in the mouth, it frequently happens, from lack of time or other reasons, that it is not practicable; then the impression should be taken as directed.

From this point succeeding steps will differ according to the character of crown to be inserted. If it be an incisor, which is to have a porcelain front, a plain plate tooth of suitable size, shape, and shade should be backed with pure gold, ground to position upon the anterior portion of the cap, and united to it by adhesive wax. Sufficient wax should be used to perfectly restore the contour and to produce the most accurate *knuckling* or adjustment of the approximal surfaces of the teeth. Too much stress cannot be laid upon this latter point,—one not usually attended to. Yet all the reasons for observing it in all other kinds of contour work are no less potent here. In this procedure pure gold of thirty-four gauge should be made to com-

FIG. 237.

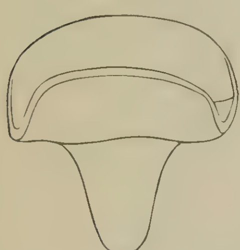


FIG. 238.

FIG. 239.

FIG. 240.

FIG. 241.

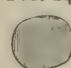


FIG. 242.

FIG. 243.

pletely envelop the sides and incisive portion of the wax, including the edges of the backing and contiguous portions of the cap. All should now be invested, the wax removed by boiling water, drying effected by a gentle heat, and the resulting golden pocket filled with twenty-carat solder. The solder, previously cut in small squares, is to be dropped into the mouth of the mold, and sprinkled with a very little powdered borax,—repeating this process with the left hand as fast as the solder is melted under the blowpipe while held in the right hand until the mold is quite filled. To accomplish this in the best manner the flame of the blowpipe should be quite intense, but at the same time exceedingly small.

The small and deep mold formed by the gold shell enveloped in the marble and plaster matrix has a very narrow opening, which renders necessary an intense heat, capable of concentra-

tion upon and easy application to the innermost recesses of the mold, which is to be filled with molten gold. An oxy-hydrogen blowpipe* was therefore constructed to utilize the condensed nitrous-oxide gas in combination with common illuminating gas for the production of a mixture which is conducted through a thin rubber tube of one-eighth inch bore to a very small blowpipe, which emits a steady flow of constantly ignited gas in the form of a pointed pencil about half an inch in length by one-quarter of an inch at its greatest diameter. With this blowpipe in hand, the plaster matrix may be speedily heated by playing the stream of fire over its surface until the mass is aglow, when the point of the flame is thrown into the mold by rapid thrusts until the solder melts like wax and fills every part of the mold with liquid gold. From the first application of the flame to the previously dried and warmed matrix, there is usually no more than ten minutes consumed in bringing the solder to the fusing point and completing the cast of gold in the little mold. It would seem that by such means only can the requisite heat be obtained, directed and controlled with the sensitiveness of adjustment that admits of the twenty-carat solder being melted in, yet without destruction of, the thin gold crucible within the matrix. After cooling, removing investient, and boiling in acid, superfluous solder can best and most expeditiously be removed by corundum-wheels on the engine. Care should be taken not to cut away the gold forming the approximal knuckling, and to artistically carve the palatal portion.

Fig. 238 represents a band of collar-gold, twenty-two carats fine, twenty-eight gauge; Fig. 239, a soldered collar or ferrule made from it; Fig. 240, a square gold pin, twenty-carats fine; Fig. 241, a plate of pure gold, thirty-four gauge, for a cap; Fig. 242, the collar, cap, and pin duly invested. Fig. 243, represents the collar, cap, and pin soldered together with twenty-carat solder; Fig. 244, a lateral incisor plate-tooth, backed with pure gold, twenty-eight gauge, ground to the anterior portion of the cap, fastened to it with wax, contoured to represent a natural incisor, the approximal sides as well as incisive portion of which,

---

* See p. 49, Fig. 26.

together with the edges of the gold backing and contiguous parts of the cap, all enveloped in pure gold, thirty-four gauge. Fig. 245 represents the same, invested in calcined marble-dust and plaster, the wax removed, disclosing the golden pocket ready for the reception of the solder. Fig. 246 shows the crown after the soldering has been effected ; Fig. 247, the lateral incisor crown divested of superfluous solder and completely finished.

In constructing a cuspid, its natural palatal characteristics should be as accurately reproduced as practicable, Figs, 248, 249, 250, 251, 252. The formation of a porcelain-faced bicuspid is

FIG. 244.

FIG. 245.

FIG. 246.

FIG. 247.

FIG. 248.

FIG. 249.

FIG. 250.

FIG. 251.

FIG. 252.

FIG. 253.

FIG. 254.

FIG. 255.

similar to that which has just been detailed, up to the soldering of the backed tooth to the cap, Fig. 253. The subsequent stages, however, are very different. The perfect configuration of a bicuspid should be reproduced in wax, aptness of occlusion and knuckling being carefully attended to, Fig. 254. In this condition the crown should be placed in a small ring, such as is shown in Fig. 255, first set with wax in the desired position, and then secured there by plaster. The exposed portion of the crown and surrounding plaster should then be coated with sandarac varnish and molded in marble-dust and glycerin, contained

in a corresponding annular section, Fig. 256. Over this is to be placed a conical tube, such as is represented in Fig. 257, and into which molten zinc is to be poured. With the die, Fig. 258, thus cast, in accurately reproducing the natural cusps and sulci, there can be obtained with pure gold plate, thirty-four gauge, a perfect counterpart of the grinding surface of a bicuspid crown, Fig. 259. The palatal cavity of the impression thus made in the plate must now be filled with gold solder, twenty carats fine, after which the piece must be finished up by any requisite trimming. Care should be taken to leave the palatal cusp entire, and just enough of the buccal or external cusp to combine with

FIG. 256.

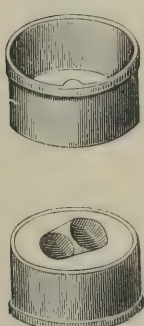


FIG. 257.

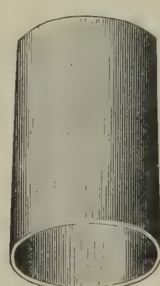
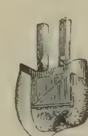


FIG. 258.

FIG. 259.

FIG. 260.

FIG. 261.



the porcelain face in the formation of a proper occluding surface, Fig. 260. From the model, as represented in Fig. 254, sufficient wax must now be displaced to permit of the prepared gold cusps assuming their proper position, and the approximal surfaces remaining in the wax then enveloped with pure gold, thirty-four gauge. The palatal portion of the collar must be protected with a strip of pure gold, twenty-eight gauge, one-sixteenth of an inch in width. All is now ready to be invested, Fig. 261. After removal of the wax, through the palatal aperture remaining, the internal walls of gold will be disclosed, Fig. 262. By careful manipulation with the small and intense blowpipe flame before mentioned, twenty-carat solder can be so flowed in as to make a

solid golden mass, from which can be readily shaped a perfect bicuspid, Fig. 263.

In the construction of an all-gold bicuspid crown some of the steps differ from those just described. Upon the cap are dropped several beads of wax. From this shapeless mass is

FIG. 262.

FIG. 263.

FIG. 264.

FIG. 265.

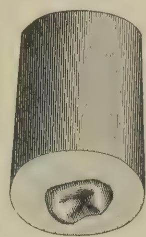


FIG. 266.

FIG. 267.

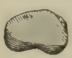


FIG. 268.

carved a perfect bicuspid, Fig. 264. A die is then obtained, Fig. 265, after the manner just detailed. A grinding surface is swaged in pure gold, Fig. 266, and the cusps are filled with twenty-carat solder, Fig. 267, and placed in proper position

FIG. 269.

FIG. 270.

FIG. 271.

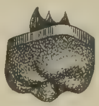


FIG. 273.

FIG. 272.

FIG. 274.

upon the wax tooth. A piece of pure gold plate, slit at the edges for facilitating adjustment, should now be made to cover about two-thirds of the yet exposed border of wax, Fig. 268. After being invested, and the wax removed by hot water, a

suitable aperture is left for soldering, Fig. 269. The resulting completed bicuspid, true to nature, is seen in Fig. 270. The descriptions just given answer for all-gold molars, Figs. 271, 272, 273, 274.

In carving the cusps and sulci, and in otherwise modeling the gold parts of the crowns, small engine corundum-wheels and points, varying from coarse to fine, and barely moistened, to insure accuracy and delicacy of touch, are preferable to files or any form of steel instruments. The smoothing and polishing is done with wet felt-wheels, fine pumice, pulverized silex, moose-hide points with chalk, brush-wheels and whiting, and finally with rouge. It is a matter of much importance that great care should be exercised in the preparation of the gold used. The solder should be uniform, flow easily, and conform well in color to the work in hand.

Dr. Shields' System.—The following methods, taken from a recent issue of the *Dental Cosmos*, is contributed by Drs. N. T. and L. N. Shields. They write in part as follows:—

The points in this work to which we desire to direct attention are its permanency, absolute cleanliness, and artistic beauty. By the methods herein described the crowns are constructed upon anatomical lines, larger at the grinding- and cutting-surfaces, so as to admit of thorough mastication of food without injury to the gums. The ordinary shell crowns are positively wrong in shape and construction, because the normal crown has a larger diameter than the neck of the tooth, therefore a band made to fit the crown of a tooth tightly will be too large at the neck. This will necessarily leave a space for the lodging of food *débris* (although it may go under the gum), will make the gum present a very unnatural appearance, will make the gold tooth altogether unnatural in construction, and the result after a very few years will be a mass of decay under the shell crown, which makes it not only a temporary operation, but a constitutionally as well as a locally injurious one.

The enamel widens or becomes thicker the nearer it approaches the grinding- and cutting-surfaces, and in order to get a perfect junction of the collar crown and the neck of the tooth we must remove *all* enamel. Their procedure is as follows: First destroy

the vitality of the pulp, then extract all of it with Donaldson's nerve-canal cleansers. With a little patience and using No. 5 all-fine, and for every sitting a new cleanser, every particle should be removed from the roots, when they should be perfectly filled to their respective apices. This done, the whole crown is cut off almost even with the gum; there will still be a thin portion of the enamel left surrounding the root, and this can easily be removed by using the No. 2 and No. 3 scalers made by the S. S. White Dental Mfg. Co. (See Figs. 275 and 276). This done, shape the root for a solid all-gold crown, as shown in Fig. 277. The procedure in the case of porcelain-faced crowns will be described later.

FIG. 275.

FIG. 276.

FIG. 277.

FIG. 278.

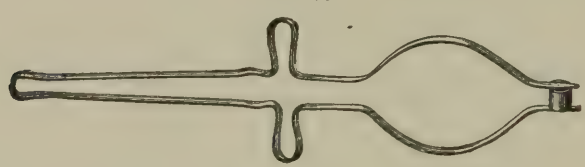
Around this conically shaped root (the removal of the enamel alone will generally shape it sufficiently) fit a twenty-two-carat gold band so as to come in contact with all parts of the conical portion of the root, which, when made, naturally gives a conical band. To make this band, first make a tin-foil model, as seen in Fig. 278; this causes less pain to the patient. From this an absolute shape in gold is obtained more quickly, and a saving of gold results. This band is soldered with twenty-two-carat solder, then placed in position, and its free margins ground down even with the root-end.

Next prepare the band for a pure-gold floor by taking a Butler corundum-point and hollowing out the upper or small end by beveling from the inside edge so as to allow room for the solder. Although only an infinitesimal amount of solder runs inside, still there must be a place for that little to flow; otherwise the band could not go back into place, on account of the solder flowing inside, and we must have the solder to flow inside in order to make a complete cone externally. Now take a piece of pure gold (No. 34 American gauge) and cut just a little larger than the band, anneal it, and adapt it perfectly, then place the two in a No. 7 Melotte soldering-clamp (Fig. 279), and be sure they

do not move; place borax, mixed with water to a thin cream, all around the overlapping edge of pure gold, place a small piece of twenty-two-carat gold solder at the junction of the band and floor, and with a broad, gentle flame solder the entire floor with the one piece of solder and at the same moment. The clamp holds them firmly together, and the work can be placed back on the tooth without rocking. (Fig. 280.)

Now make the pivots or dowels (of platinum and iridium wire), and roughen them before placing in position. Drill holes corresponding with the root-canals, place the pivots in position, and fasten them to the floor with prepared hard wax. Now remove carefully, and invest pivots, floor, and band in equal parts of plaster and marble-dust, and after removing the wax with boiling water, unite them with twenty-two-carat gold. Now cut down

Fig. 279.



the overlapping pure-gold floor exactly even with the band, also cut down the projecting ends of the pivots. This constitutes the foundation for a solid gold crown. Never make pivots for canals which cannot be thoroughly filled with cement. It is better to shorten the pivot somewhat and make it thicker, and depend for anchorage only upon the lower part of the canal, as shown in Fig. 281.

Now put the foundation in its position in the mouth (upper jaw, for example), and take an impression of the whole upper jaw in modeling compound, also take an impression of the whole lower jaw. Remove the foundation, and place it with great care exactly in its proper matrix in the impression just taken, then stay it to the modeling compound with wax in two or three places; be careful not to move it with the wax knife, dry the pivots and band on the inside, and cover the pivots with a film

of wax, also run a film of wax around the band on the inside, but be sure to remove all wax from the edge of the band, because we want that to rest firmly upon the plaster. Now fill the impression with plaster to make a model.

After separating the model, remove the crown foundation from the model by making a hole, usually on the palatal surface, with a pocket-knife, through the plaster to the apical end of the pivot. Now place the model and foundation in hot water, and with a little pressure on the end of the pivot the whole foundation is easily removed. Syringe out all wax from the model and foundation; the latter should then be replaced upon the model.

Next make the stamp for a grinding-surface; use for this pure gold, 34 American gauge, and fill in the cusps with twenty-two-

FIG. 280.

FIG. 281.

FIG. 282.

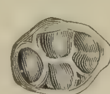


FIG. 283.

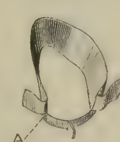


FIG. 284.

carat solder. Melotte makes a very fine set of steel stamps that one can generally make use of, but a zinc cast can be made in a few minutes by simply placing White's prepared molding-sand, always ready for use, in a ring and gently embedding the grinding-surface of a suitable tooth, and in a minute by the watch a small quantity of zinc can be melted and poured into the impression in the sand. The molar or bicuspid stamp is made in the usual way by placing the pure gold, always well annealed, on a piece of lead and striking a few light blows on the die, which gives a perfect grinding-surface, as seen in Fig. 282. This is the reverse side of a stamp of a superior left first molar.

Next trim off all surplus gold, leaving the grinding-surface as represented in the cut. The cusps are next filled with twenty-two-carat solder. The reason twenty-two-carat solder is used

is, when the whole space between the grinding-surface and the foundation is filled in with twenty-carat solder there is no danger of the twenty-two-carat being melted out of the cusps, and consequently no danger of having an air-bubble just under the grinding surface which, of course, would make itself visible after a few days' use.

Having taken a full impression of both upper and lower jaws, an absolutely correct articulation is secured. Now add wax to the foundation, which can be removed from the plaster, until an exact articulation with the pure-gold grinding-surface is produced. After having gotten this with hard wax so that it may be manipulated without disturbing its position, continue to build out the tooth to its anatomically correct contour with wax, frequently trying it into place. After the foundation is removed from the plaster, the plaster is cut away from between the foundation and the adjoining teeth without disturbing the plaster upon which the band rests. When this plaster is removed, wax is added up to the very edge of the band, so that the entire anatomical contour can be restored with gold, including even that of the enamel chipped off at the cervical margin. The wax tooth should always be tried in the mouth, to be sure that everything pertaining to form, contour, and position is just right. This was the object of removing the foundation from the plaster model at the outset, as it is a great advantage, and particularly so with facings, to always just at this time try the tooth in the mouth.

Now from a piece of tin foil (No. 60) a model is cut so as to fit the wax exactly. We cut the gold on the palatal surface from the height of foundation (see A, Fig. 283), thereby enabling us to join the free ends at the cervico-palatal surface. The large ends of the gold we turn out and back, to stay it in the investment of plaster and marble-dust. The gold can be cut a little long, to allow of bringing the cervical ends together. This cervical margin is very important, as shown in Fig. 284. Sometimes three pieces of gold are used instead of one, but if so the pieces of gold should always be cut with projections (as seen in Fig. 283) to retain the exact shape of the tooth and not pull it from the instrument when soldered. This gold band

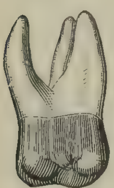
must fit just under the edge of the grinding-surface stamp, and be in perfect contact with it, so as not to allow the grinding-surface to move. This little thickness of pure gold (No. 34 American gauge), must be allowed for waxing up the tooth.

Now we have the wax tooth thoroughly boxed in, excepting the palatal surface. Before taking the next step, be sure that the pure gold band for boxing is in contact with the cervical margin of the foundation-band. At the point of junction here and at the grinding-surface place a little wax, and then cut all possible surplus away, leaving only the very junction filled; also be sure no wax gets on the inside of the cervical margin of the foundation-band. Now place the tooth in water and invest it in plaster and marble-dust, covering the whole tooth except the palatal surface of the crown; the plaster must just cover the narrow gold joined at the cervical margin. After the plaster sets, boil out the wax and cut the investment as small as possible, leaving the plaster only about one-eighth of an inch all around. Now dry thoroughly, but not in contact with a flame; have something—a top of a tin box, for instance—between the flame and the tooth. After it is dry, place it in the flame of a small Bunsen burner. To hasten the heating-up process, a foot blowpipe may be used to get it red hot very quickly, but nevertheless the heating up is to be done cautiously, and during this time we still have the little Bunsen flame under it. Now by applying the flame of the Knapp blowpipe the gold flows with the greatest ease in all parts and in all directions. Here use twenty-carat solder. Fill the molar about half full with gold, using borax as a flux, before using the Knapp blowpipe.

It should be observed that we have the solder almost to the melting point, everything is red hot, and a hot flame beneath the investment, so that when we gently apply the Knapp blowpipe flame the gold simply drops, and while in this molten condition add the rest of the solder, never allowing it to cool for one moment, for if it does air-bubbles will result. Here the gold boxing-band at the cervico-palatal margin does its work beauti-

fully; the gold flows freely all around, with no danger of solder running inside the foundation from the palatal side. The plaster and marble-dust should always be worked as stiff as possible, so as to always have the gold in contact with plaster, which will not be the case if the investment is mixed thin. The necessity of having everything firmly held, so that the gold solder will not pull it in and change the entire shape of the crown, becomes evident when the large amount of solder used is considered. This being a solid crown, we put it in water to cool, and next in very dilute sulphuric acid, and gently heat it to remove adhering borax and oxidation. Now we can shape the gold to anatomically correct contour lines and bring the cervical margin down to a feather-edge, so that when again placed on the root we have an absolute junction without a lodging place for acids, and the whole tooth restored to a state of perfection. (See Fig. 285).

FIG. 285.



In the construction of a crown with a porcelain face, the root is shaped just as for a solid crown, excepting that it is cut under the gum on the labial surface, and also lower on the palatal surface, so as to remove all enamel (Fig. 286). After cutting under the gum hold the gum back by anchoring premium gutta-percha in the root-canal and press it over the labial surface. After the crown has been set, the gum comes down beautifully over the gold band and prevents its being visible. Prepare and complete the foundation the same as for the solid crown, taking impressions, bite, etc., as before, and select the shade. Now prepare the facing carefully as follows: Grind the facing shorter than you desire by the thickness of No. 34 gold plate; grind off both angles left at the cervical portion, and also grind the cutting-edge on the palatal side from pins to cutting-edge, leaving a feather-edge at the cutting-surface; likewise grind the cervical portion from pins to cervical margin, leaving this margin also a feather-edge; also remove angles from pins to approximal margins, the object being to give a perfectly convex contour to the palatal side of the facing.

After grinding off the heavy angles with the lathe, use disks in

FIG. 286.

FIG. 287.

FIG. 288.

the engine, and be sure that all angles are removed. Sometimes it is even necessary to go between the pins with a disk. Now take Scotch stone and make the surface perfectly smooth, edges particularly, or the gold cannot be brought in absolute contact. Three different views of a facing so prepared are shown in Fig. 287. The surface where the pins are being the highest part, the grinding of the palatal surface is done so as to fill in with twenty-carat solder and give all the strength that would be obtained if we ground the cutting-edge off square, for when the tooth is finished we have a slightly beveled surface of gold at the cutting-edge, the facing having only a feather-edge; but that edge is well protected, so we get great strength. We secure, besides, artistic beauty by having the facing exactly the shape of the natural tooth on the whole labial surface. By this method of shaping the facing we never have a tooth to crack, because there are no angles, and finally the solder will flow perfectly around the cervico-labial surface.

Now take this facing (being sure that the palatal surface is clean) and back it with pure gold, No. 34, allowing the gold to project a little at both cervical and cutting-edges. In order to back this facing so that the pure gold is in absolute contact with the facing, anneal several times, each time pressing it in contact with the facing with a broad instrument like a plastic spatula No. 20 (Fig. 288). Never stop annealing and working to place until the tooth can be held in contact with the backing at the cutting-edge and permits no motion of gold at the cervical margin. The same with the approximal surfaces. Now hold

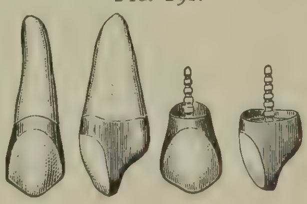
the tooth and backing between the thumb and middle fore fingers tightly, and with the point of a pocket-knife push the gold into hard contact with the pins all around, using the very point of the knife, and there will be no occasion to bend the pins; besides, it makes a perfect gold surface.

Place the facing with its backing on the foundation, wax up with hard wax, and try it in position in the mouth. If doubt exists as to the correctness of the position, stay it well with hard wax, then try again for position. After obtaining it, finish waxing up until the contour is anatomically correct, leaving a little margin all around the backing so as to be perfectly boxed in. This, is done just as in the case of the molar, by making a tin-foil model (Fig. 289) and bringing the gold into absolute contact with the backing, because if a small space is left borax will

FIG. 289.

FIG. 290.

FIG. 291.



run through and crack the tooth. Great care must be exercised with regard to this contact.

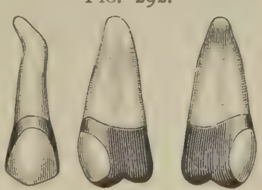
This cuspid box may be made in two pieces, joined at the cervico-labial surface the same as seen at the cervico-palatal and cutting-edges. When we bring the gold across the cutting-edge, which has the gold projecting a little, not bent over the edge, but projecting in perfect contact, make the pure gold go just a little lower than the cutting-edge, so as to have a little bevel of twenty-carat gold, so slight that it cannot be seen (Fig. 290). For exceedingly heavy use leave the bevel a little thicker, but even that is scarcely noticeable. Now fill in the junction of the boxing with the backing, and also of the cervical margin of the foundation with wax, and invest the same as for a solid crown, allowing the plaster and marble-dust to come over the cervico-palatal boxing, etc.

To solder this crown, place but a few pieces of twenty-carat solder and borax in before using the Knapp blowpipe, because we want the first gold to flow perfectly at the cervico-labial surface and so avoid air-bubbles, after which the course is clear. After the soldering is completed, place the crown under a little box, so that it may cool off slowly and no draught can reach it. When cold, boil in dilute sulphuric acid. This gold will cut down absolutely in contact with the tooth, and when the cutting-edge is finished with a slight bevel, it will be seen and understood what great strength has been secured, with, at the same time, a beautiful labial facing of porcelain. When the cervical surface, in fact, the whole crown, is finished up in the thorough and artistic manner of which it is capable, it becomes a piece of perfection. (See Fig. 291.)

A bicuspid is made exactly the same as a cuspid, with the exception of the stamp. Make the stamp, and fill the cusps with twenty-two-carat solder, then hollow out the buccal cusp to fit the cusp of the facing, and place a very narrow piece of pure gold at the junction on the buccal surface, and continue as in the cuspid. (See Fig. 292.) If the bicuspid is a short one, do not be afraid of cracking the facing; grind and make it exactly as directed, and it will not crack. Notice the curve in the bicuspid cut.

For a bridge-tooth, take a superior right cuspid. Now when grinding a tooth to fit the gum we necessarily expose the small porosities in the body of the tooth, which always have a tendency to lodge food, thus producing an offensive breath. To correct this defect, shape up this cuspid exactly the same as if we were making a crown, and back it up the same way. Now flow wax over the whole surface, and regulate the thickness of the wax according to the required fullness of the tooth, boxing in with pure gold the height of the wax and restoring the shape of the lost tooth; then invest to the top of the boxing, and after the proper steps of investing fill in with gold. Here there are two great points to observe. First, this gold

Fig. 292.



can be finished absolutely smooth, so that nothing can collect in the way of food, hence nothing but perfect cleanliness can exist. Secondly, any amount of absorption of gum can be counteracted by building out with gold exactly the amount of absorption. This will give the tooth a natural position, a perfectly smooth palatal surface, and restore the lip to its normal (or, in case of a cuspid, almost normal) expression.

Dr. Low's Method.—The following description of an original method of crown replacement was prepared by Dr. J. E. Low, of Chicago, Ill. The inventor claims exceptional advantages for his method, and has also presented them to the profession in connection with bridge-work, which article we also introduce under its appropriate head in another place.

"This crown is the result of an effort to overcome the many objectionable features to be found in other crowns in use at the present day.

"Having had an extensive experience in crown-work, with a thorough knowledge of all crowns in use, and with the many letters now before me from various parts of the country, containing testimonials to this effect, I think I can justly claim that this crown is nearer to perfection than any other before presented to the notice of the dental profession. I am aware that the average dentist does not differ from the rest of humanity at large in the matter of changing their mode of operating, and when any new improvement is presented to them, they at once begin to see what objection they can raise against it, instead of recognizing its good qualities and advantages over others. As I have had a good opportunity to know most of the objections raised against the crown in question, I think it best here to mention those of importance and show how incorrectly they have been drawn.

"Now, I do not wish the reader to think for a moment that I object to criticism, providing it is just, for this would assist me in regulating what imperfections there might be, to the benefit of all. One of the most common objections raised by those who have never used the crown, is that the instruments cut away too much tooth substance in preparing the root, and the walls of the tooth are thereby weakened.

"Then, again, some claim that it is necessary to have a band around the tooth to prevent it from splitting. The other objections are not of enough importance to notice. I will now proceed to set a crown by this method, and if, in so doing, I am

FIG. 293.

clear and comprehensive, I think all will agree with me in saying these objections are not well founded.

"By carefully looking over the case of instruments represented in Fig. 293, you will find there are seven in number, instrument No. 1 being the smallest. This instrument can be used in more

cases to advantage than any other. Almost all the laterals, and nearly all the bicuspids, as well as all badly decayed molars, when so decayed that gold crowns cannot be used, and, in fact, any tooth that is generally set down as beyond restoration, can be crowned successfully with this instrument.

"We now have before us, Fig. 294, a central incisor badly decayed. The first step to be taken to crown this root with a strong and serviceable crown, is to cut or grind even with the gum what tooth substance remains. We start off with the supposition that the root is in a healthy condition; if not, it must first be treated, and made so, as this is the first consideration in the final result of a successful operation. The next step is to select the instrument in accordance with the size of the opening in the root to be crowned. The larger the opening in the root, the larger the inside or center cutters must be, and the narrower the cutters that bevel and prepare the end of the root. The reason of this is that the space is nearly all taken up by the inside cutters, in order to reach and cut away the decayed tooth substance, and prepare the root to properly receive the step-plug with bevel cap, which covers the end.

FIG. 294.

"We have seven sizes of instruments to select from, and when properly selected, no tooth substance that ought not to be removed will be, cutting as they do the least where the tooth is smallest, or, in other words, cutting the opening in the tooth in the same shape as the root—tapering.

"These cutters leave the root in the shape of Fig. 295 with graded steps. We next select the graded step-plug as seen in Fig. 296, the same number as the instrument, which will perfectly fit the opening, and cover the end in a beveled saucer shape, and by its attachment when cemented makes a combined union of strength, unequaled by any other crown, and thus it is made impossible for the root to split. In Fig. 297 we have the step-plug placed in position.

FIG. 295.

FIG. 296.

FIG. 297.

"After placing the plug in position, an articulation of wax, and

an impression of the space to be supplied, and a few adjoining teeth, are taken in plaster-of-Paris. Before taking the impression, be careful that the pin which extends from the cap of step-plug for the purpose of removing is free from all roughness (a roughness that is sometimes left in the cutting of the plug), as this is liable to break the plaster when removing the impression from the mouth. I generally file the step-plug on a slant from the labial side to the center, so that there will be no mistake in replacing the step-plug into its proper place in the impression. After placing the plug back in the impression, if necessary, take a thin, heated spatula, and stick the plug fast with a little hard wax on the outer edge, so that it may not be dis-

FIG. 298.

FIG. 299.

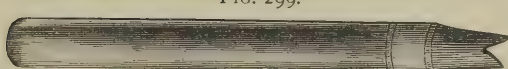
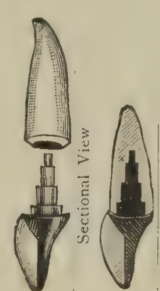


FIG. 300.



turbed in pouring. Be careful not to get any wax on the part of the plug where you do not want solder to flow in. Now varnish the cast in the usual way, but do not touch the plug with the varnish. Next, pour with plaster and sand, asbestos or pulverized pumice stone, any one of which will do. After the plaster is thoroughly hardened, carefully cut it away in the usual manner. Place the articulation in the articulator, and pour in the usual way. The tooth is selected, and we proceed to back the same in the following manner: *First*, grind and fit the tooth to the cast and cap to suit you; then cover the entire inner surface with thin platinum, the thinner the better. Burnish close to the surface of the tooth. Then use 28-gauge platinum for a backing down to where the tooth is ground out to fit the step-plug, and

bend the pins down to hold the two pieces of platinum tight to the tooth. We now have Fig. 298 representing the tooth as it appears backed ready to place in position. Next place the tooth in position in the cast, cover with plaster and sand, and solder with gold coin. After finishing and polishing, the crown is ready for adjustment. Moisten the step-plug and cap with cement, and with the little roter, seen in Fig. 299 or in the case, gently press the crown up in position, and we have the crown completed as seen in Fig. 300.

"Should you desire a cheap crown, you can solder with block tin. After experimenting with various metals, I have succeeded in making a step-plug or tip of platinum and nickel that is as strong as steel and cannot be melted. In the above description I have given my way of making the crown. This given in detail seems like a long, tedious method, but it is very short; and as I always keep a laboratory man, but very few minutes of my time are consumed in making and setting a crown, not exceeding twenty minutes in any case, as I only prepare the root, take an articulation and impression, and, with the shade of the tooth, hand in to the laboratory man. When my patient returns, providing the crown is not made while I am doing some other work for the same party, it takes me from ten to fifteen minutes, counting the setting of the cement, to adjust the crown.

"The above is my manner of setting the crown in order to save time at the chair. Should I perfect the crown myself, I should take a shorter way, viz.: after preparing the root with the instrument and placing the step-plug in position, my tooth is selected, ground, and arranged in the mouth, after which I back the tooth as before described; then soften a little piece of hard wax, made of resin, gutta-percha, and beeswax. I warm and stick a small amount of this to the backing of the tooth, place the tooth in position in the mouth, perfectly embedding the top of the step-plug in the wax. Great care must be exercised here to have the tooth in the position desired, in pressing the tooth and wax against the plug. I next carefully remove the wax and tooth, and with pliers remove the step-plug and place in the impression just made. Then with a heated spatula stick the tip and wax together; pour in the usual way, and in a

few minutes it is ready to solder. In this way a crown can be set easily in one hour's time.

"If you wish to crown a bicuspid or molar tooth, your first step is to grind what little tooth substance there may be down even with the margin of the gum and then use your drill. In drilling, instead of following the nerve cavity direct, which would leave the instrument a little diagonal, hold the instrument perpendicular. This leaves the upper portion of drill to the outer wall of the root, and brings the lower portion of drill to the inner side of the root. There would be danger of puncturing the wall of the root, should you continue going deep enough, but there is no need of going to such a depth. Then take the No. 1 cutter, which will invariably be the instrument to operate upon all the bicuspid and molar root canals, and after cutting to the depth desired, the root is ready for the introduction of the first step-plug of same size. We now drill one other root in the same manner, and, after placing the step-plugs in position, take an articulation and impression, remove the plugs, and place in the impression; pour and separate, and place in the articulator as described before. We now have an exact impression of the root to be crowned, with a few adjoining teeth.

"Next take a thin piece of platinum and make two perforations for the pins on the ends of the step-plugs to enter; press the platinum down over the root and burnish close to it; then remove the same and trim by the marks made in burnishing to the exact shape of the root. Place the platinum on the root again, and we are ready to select our tooth. This should be made the same as is used for bridge-work, with gold cusps, so no breakage can possibly occur. Now place the tooth in position in the articulator, holding it in place with wax. Encase in plaster and sand, fill in and solder up with gold coin; or, if you choose, block tin can be used. After polishing and burnishing, you have a strong, durable crown, only equaled by the natural tooth, ready to be adjusted.

"The setting of a bicuspid is similar to that of a molar. In this operation we seldom use but one step-plug.

"In Fig. 301 we have the root cut ready to receive the step-plug.

"In Fig. 302 we have the step-plug with the platinum attached, which covers the entire tooth surface.

"In Fig. 303 it will be seen that the cap of the step-plug goes below the surface of the tooth, leaving tooth substance all the way around; but the platinum that is soldered to the step-plug rests on the tooth surface.

"In Fig. 304 we see the crown ready for adjustment.

"Fig. 305 is the tooth after it has been adjusted

"These plugs can be used to great advantage in varied dental operations. There is nothing equal to them for restoring broken and decrepit teeth to their original usefulness. I use them exclusively in bridge-work. They make a firmer, stronger, and more durable groundwork for bridging than any other method I have ever discovered. In badly-decayed molars, where there is not sufficient tooth substance to hold a gold crown for bridge,

FIG. 301.

FIG. 302.

FIG. 303.

FIG. 304.

FIG. 305.

I always place one of these plugs in the root, which makes a solid foundation. If the pin on the end of the plug for removing is not long enough, it can be very readily lengthened by soldering a piece to it without danger of injury or melting the same. The plugs are made of a perfectly non-corrosive metal, although the color might indicate otherwise. They are strong as steel, and cannot be melted by heat from an ordinary blowpipe."

Dr. Büttner's Method.—Dr. H. W. F. Büttner, of New York, to secure the attachment of a porcelain crown to the root, has made available the mechanical device known as a mortise-joint, the root being shaped by trephining to the form of a tenon, a gold band or ferrule forming the mortise. The following is his description of the process:—

"In my method of setting artificial crowns, I claim simplicity

of construction, firmness, durability, and arrest of decay of the root (Fig. 306). From the following description of my method it would seem that a failure would be almost impossible. To protect the end of the root from decay, and to obtain a strong hold for an artificial porcelain crown, a gold band, properly applied, must be of the greatest benefit. I am aware of the fact that gold bands have been applied, but I am convinced that their adaptation after any of the old methods is defective. What I claim in my method is the preparation of the neck of the root by a set of instruments especially constructed for that purpose. These instruments enable the operator to obtain as nearly perfect adaptation between the gold band and the root of the tooth as can possibly be made. With reference to the upper centrals, laterals, and canines, as well as the corresponding lower teeth and bicuspids, there can be nothing more favorable than the application of this method. It is true that this process cannot be applied with the same advantage to the upper bicuspids or any of the molars, but I hope in time, if I am in any way supported by the profession, to solve that problem. I believe I will succeed in constructing a set of instruments which will prepare a root the pulp of which is alive, and may, if healthy, be readily kept so. But as this set of instruments is not quite completed, I will abstain from its description, and only allude to the setting of crowns which require the devitalization of the pulp, unless this organ has previously died. With these instruments a circular shoulder is turned on the neck of the root.

FIG. 306.

"The alteration of the neck of the root from an irregular cone to a cylindrical form enables us to adapt a corresponding ring or cap. Such a cap, when fitting accurately around as well as upon the end of the root prepared by these instruments, forms an air-tight joint, and consequently protects it from decay, at the same time giving the porcelain crown, when attached, a firmness which heretofore has never been obtained. The set of instruments by which the neck of the root is prepared consists of drills, reamers, and trephines. The drills (Fig. 307) are used to enlarge the root-canal for the guidance of the reamer or facing

instrument and trephine. The reamers (Fig. 308) cut the surface of the root down as far as necessary. They produce a perfectly level surface and have a center-pin, which corresponds with the hole made by the drill in the center of the root, and acts as a guide. The trephine (Fig. 309) has also a center-pin, and is used to make the root cylindrical below the free margin of the gum. A set of these instruments includes different sizes of drills, with reamers and trephines corresponding in size adapted to various diameters of roots.

"The ferrules or caps (Fig. 310) to fit roots which have been prepared by the above instruments are of gold, made by steel dies. They correspond exactly with the trephine in diameter

FIG. 307.

FIG. 308.

FIG. 309.

FIG. 310.

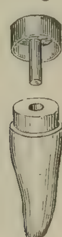


FIG. 311.

and depth, with allowance for sufficient expansion of the gold when forced on to the shoulder of the root, whereby a most perfect joint between cap and root is obtained. They have a stout central pivot which fits the hole in the root and gives increased strength and firmness.

"The pulp-canal is enlarged with one of the drills selected with reference to the size of the root. A reamer corresponding in size is used with the dental engine to cut the root down to a perfect level. The trephine is applied in the same manner to give a cylindrical form to it, thus completing the shoulder (Fig. 311).

"A steel wire corresponding in diameter with the drill which

has been employed is now introduced into the root, projecting about half an inch. It serves to indicate the exact direction of the root-canal. An impression-cup is selected with an opening opposite the missing tooth to take an impression of the root and adjoining parts. The object of the opening is to give free transmission to the wire in the root-canal. The wire protruding through the cup and impression-material is drawn out carefully before the removal of the impression-cup, which is then removed and the wire placed in its proper position in the impression. A set of brass root-models (Fig. 312) corresponding in size with the instruments accompany them; one of these, bearing the same number as the instrument with which the root has been prepared, is now placed on the wire in the impression, and serves to represent the prepared end of the root on the model. The impression is now ready to be filled with plaster. After the cast is obtained, we find the root-model imbedded in the plaster and the wire in its center-hole. The wire is removed and the plaster cut from around the root-model to the depth of the gold cap, which is ready to be placed upon it. A plain porcelain tooth (Fig. 313), as used in plate-work, is ground hollow on the inner surface to cover the outer front wall of the cap, thus hiding the gold. Thin platinum backing is adapted to the tooth, which is then ready to be placed in position on the model over the gold cap, and fastened thereon with hard wax. The united parts are removed carefully from the model, invested in sand and plaster, and soldered. After polishing, the cap is ready to be forced upon the root by placing a piece of wood on the cutting-edge of the tooth and driving it home with a mallet."

FIG. 312.

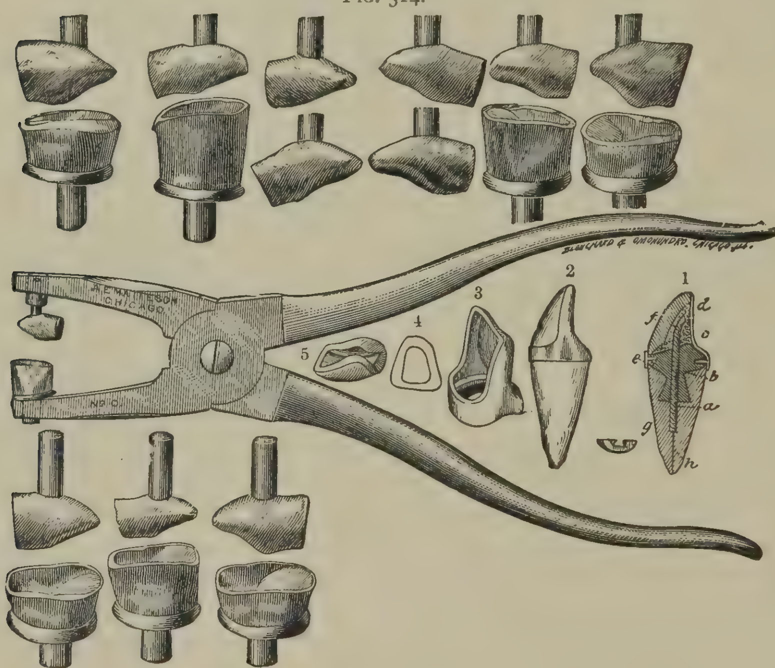
FIG. 313.

Dr. Matteson's System.—The following process of forming and attaching a porcelain-faced crown, taken from the *Odontographic Journal*, is the device of Dr. A. E. Matteson, of Chicago, Ill. The method of constructing a shell in conformity with the general configuration of the natural crown is unique and original, while the facility with which it can be so shaped, the accuracy and security of its adjustment to the root, and the ready manner in which the porcelain face may be replaced in case of accident,

are points of excellence that entitle the method to rank among the higher forms of substitution. The several appliances used are exhibited in Fig. 314. Concerning the process, the inventor says :—

" The gold-and-platinum plate gives the greatest strength without an excess of material, permitting the use of a higher grade of solder than could be employed were gold alone used, without the consequent danger of melting the shell ; and being

FIG. 314.



of uniform thickness, its thorough adaptation to the end of the root is rendered a matter of comparative ease and certainty. It also permits the use of amalgam, the strongest cement we have, for anchoring the crown without danger of injury to the gold. I will say, however, to those who are opposed to the use of amalgam, that gutta-percha, or any of the cements, can be substituted, and with as good results as in any other position in the mouth.

"The opening in the front of the shell gives an opportunity to see that the filling is properly introduced, thoroughly condensed, and is not guesswork.

"The porcelain front is not dependent upon a few small pins for support, but upon the dovetailed slot, further supported by the edges of the shell, which entirely surround it; and in case of fracture, a new front can be easily inserted without removing the shell.

"Of no small importance is the ease with which this crown can be made. Even in the hands of those unaccustomed to metal work, good results may be obtained.

"The forceps, with a set of eleven dies and counter-dies, are all that are required in addition to the instruments usually in possession of a dentist in practice.

"The root upon which the crown is to be mounted should be placed in a healthy condition, with the nerve-canal filled at the apex, the end ground off *below* the free margin of the gum in front, and within an eighth of an inch of the gum on the inner or lingual surface, the end of the root countersunk, and the nerve-canal enlarged sufficiently to receive a platinum wire—No. 18 or 20, standard plate gauge—with a screw-thread cut thereon. This should fit tightly enough to take firm hold. Further enlarge one-half the length of the nerve-canal with a cone-shaped bur, with its base toward the apex, as represented in the accompanying cut, No. 1.

"Previous to grinding the end of the root *below* the gum in front, take a measurement of the circumference of the root at the margin of the gum with fine binding wire. Cut across an intersection and carefully remove the wire ring thus formed, without changing its shape. Take an impression of its form by placing it between a sheet of writing paper and a smooth surface, and by rubbing the end of a finger thereon the outline will appear. This is the outline of the end of the root; from this cut a pattern.

"Select a die similar in shape to the tooth you wish to reproduce. Make a pattern of the shell by pressing between the dies a piece of thin copper or pattern tin, leaving an opening in front, with a band extending around in front, as represented in

No. 3, the cut being on a line with the edge on one side. Remove this pattern and press into as plain a surface as possible.

"Cut the gold-and-platinum plate to pattern, making it wider or narrower, as the wire measurement of the end of the root compared with the pattern indicates. Anneal and place the plate in the same position between the dies as that previously occupied by the pattern; and press into form, remove, bring the edges together without lapping, and solder with pure gold. The shell may be made longer or shorter, wider or narrower, than the die upon which it was made, as the case demands.

"To fit the shell to the root, trim the root end of the shell until it occupies its proper position and the articulation is correct, which is determined by the patient closing the teeth. The corners at the cutting edge and sides should be cut, and the edges brought together without lapping, and also soldered with pure gold.

"Now, from platinum plate No. 30, cut the ring, No. 4, to the paper pattern. This forms the shoulder within the shell. Place the shell in position on the root (the teeth closed), insert the ring, which should rest upon the end of the root midway the width of the band in front, and should fit the shell tight enough so that both can be removed without changing their relative positions. Remove from the root, and with a fine camel's-hair brush apply finely ground borax dissolved in water. At the junction of the two pieces, place a small piece of 20 k. solder on the inner surface, *i. e.*, toward the cutting edge of the shell, to prevent an excess of solder flowing between the shoulder and the end of the root upon which it will rest. Flow the solder, which should merely tack the ring in place at the front. Try upon the root to make sure of its being correct; remove, and complete the soldering. The shell may be strengthened by flowing inside, a lower grade of solder than previously used, at such places as desired.

"Select a plain rubber tooth and fit to the opening in the shell (which may be removed for the purpose), and with corundum-wheel and disk grind a dovetailed slot in the back (see No. 5), running lengthwise, and sufficiently deep to permit the platinum screw to extend two-thirds the length of the crown without interference.

"To anchor the crown to the root, place the shell in position, apply the rubber dam over it and the adjoining teeth, turning the edges well under the gum. Remove the shell (the dam will remain in position), dry the nerve-canal, insert the wire-screw, cut it off the required length, and with amalgam mixed hard fill around the screw in the root (the end of the screw should be bent against the inner wall of the shell when the teeth are closed, so as to fall into the dovetailed slot in the porcelain front when that is inserted). Continue the amalgam filling through the opening in the front of the shell around the screw and over the shoulder, as represented in No. 1; and with oxyphosphate cement, complete by filling around the wire and in the slot of the front, which is then inserted and pressed into position by the thumb and finger, the excess escaping at the edges. Burnish the edges of the shell around the neck of the root and porcelain front. Instruct the patient not to disturb it for from four to six hours.

"In conclusion, I will offer some suggestions. The dies are fitted to the forceps with the cutting edges of the teeth turned toward the handle. Be careful that the dies and counter-dies do not get mixed. Preserve the pattern of each die with which it should be left, as it will save valuble time. Apply the flux (borax) only where you wish the solder to flow, and cut the solder in small pieces, using only sufficient to accomplish its purpose.

"Amalgam may be made to set more quickly by incorporating gold with the mercury, say 5 per cent. Foil scraps are excellent.

"In case of fracture of the porcelain front, remove the pieces and fit in another, without removing the shell from the root. Cement in as before.

"The cut represents the forceps one-half size. They are one-half nickel-plated. The dies are full size, nickel-plated, and are interchangeable in the screw sockets.

"The gold-and-platina plate is made by sweating pure gold upon a plate of equal thickness of platinum and rolling to the desired thickness (No. 32, plate gauge), and can be obtained at the dental depots."

THE ALL-GOLD CROWN OR CAP.

In the construction of the all-gold crown, the sides of the natural crown and neck of the tooth are brought down to—or a little smaller than—the size of the root. This is best accomplished by the use of diamond disks and small corundum-stones on the dental engine. From the occluding surface, if any of it remains, a sufficient amount should be ground away, and the edges slightly rounded, to allow the introduction of the gold cusps. The measurement and making of the band is the same as described in connection with the Richmond collar crown (see page 227), excepting in the width of the ferrule. This should extend from the root, below the gum-margin, to within a line of the occlusion with the antagonizing teeth. After soldering and adjusting, the band should be shaped and contoured with burnishers and suitable pliers, the smooth, round-nosed, answers very nicely. The surface of the band to which the cusps are to be attached should then be brought down perfectly smooth and flat with a fine file; readjusted carefully to the root, to make sure that it has not been so distorted by the different manipulations that it will not pass readily to place and fit the root perfectly at every point. Finding all correct, the next step is making the cusp.

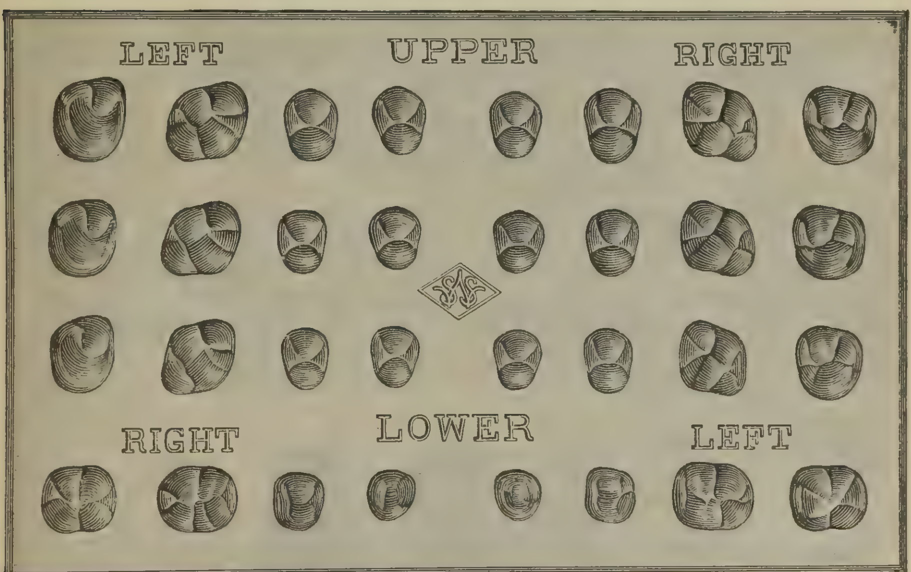
A number of methods have been put forward for making gold cusps. The two that have proven most satisfactory are the use of the die, such as described in connection with the Knapp-system of making crowns, and by means of the die plate as described by Dr. E. T. Starr, of Philadelphia, in the *Dental Cosmos*, as follows:—

"In the construction of metal cap-crowns to cover natural teeth or roots there are many methods which result in good work, but in most cases the caps do not articulate as well as they might, for the reason that means for embossing the bicuspid and molar cusps are not at hand, or available within the short time at the disposal of either the patient or the dentist. With the object of providing an easy and quick way of working under such circumstances, I have made a single plate, Fig. 315, in which are four groups of intaglio dies representing with dis-

tinctive correctness the peculiar cusps of the upper and lower right and left bicuspids and molars. These are indicated by the Hillischer notation, so that each form may be easily identified in practice.

"The hubs A B, Fig. 316, are of the sizes shown, and are made of an alloy composed of tin one part, lead four parts, melted together. The mold C should be warmed, the melted alloy poured in every hole, and the overflow wiped off just before

FIG. 315.

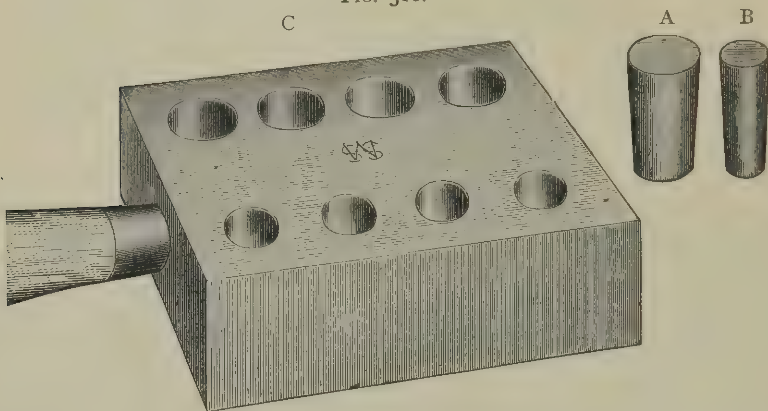


the metal stiffens. This will make the butts of the hubs smooth and flat. After a minute or two the mold may be reversed, the hubs shaken out, and the casting process continued until a considerable number of hubs shall have been cast.

"In Fig. 317 a molar hub is shown in place on a piece of No. 32 gold plate, which lies over the upper right first molar die. A succession of blows on the hub, with a four-pound smooth-faced hammer, will drive the plate into the die, and at the same time spread the hub-metal from the center to its circumference

in such a manner that the plate will be perfectly struck-up with the least possible risk of being cracked. The flattened hub is seen in Fig. 318, which also shows at D the obverse of the

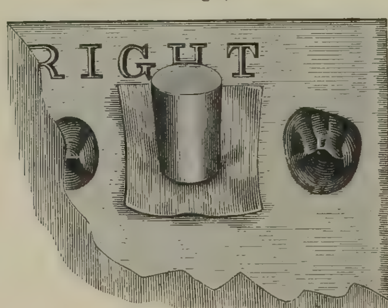
FIG. 316.



struck-up hub, and at E the cameo of the struck-up plate having every cusp and depression of 6. Fig. 319 sharply defined.

"The counter-die plate, Fig. 315, is made of a very hard cast metal, which will admit of the striking up of many crown-plates

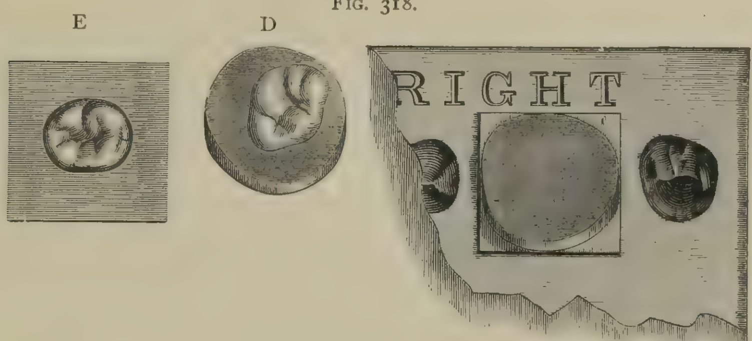
FIG. 317.



by the means and methods described, if the crown-plates be not too thick and stiff. Of course, they should be annealed before they are placed over the die. In careful hands the die-plate should give clear cusp definitions after years of use.

"For the reason that the counter-die plate is in some respects similar to a stereotype plate for printing, the struck impressions on two strips of thin plate will appear as in Fig. 319, wherein their regular order is noticeable as seen from the cameo surface of the struck plates. The peculiar action of the hub in forming first the center of the crown plate, and spreading from the center outward, as the hub is shortened under the hammer, until the die is overspread by the plate and hub, with the result shown in Fig. 318, is an essential feature of this process for obtaining easily and quickly the superior styles of coronal cameos shown. If a cusp or fissure should chance to crack in hubbing, a small piece of plate may be struck over it, or another crown plate be struck over the first and the two soldered together.

FIG. 318.



"The depressions in the struck plate can be partly or wholly filled with scraps of plate or solder, and the surplus plate cut away from the cameo.

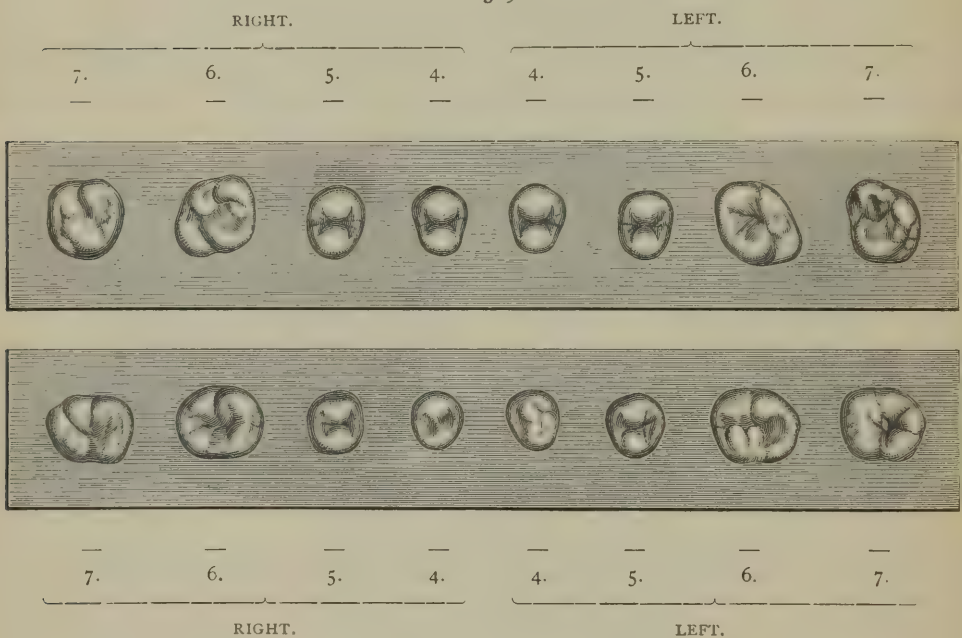
"The fact is noteworthy that, by means of the Knapp blowpipe, the coronal intaglio may even be filled with melted scraps cut from the identical plate out of which the cameo was struck. The better way, however, is to fill, say, a twenty-carat cameo with eighteen-carat plate scraps. The fitting and soldering of the doubled or filled cameos to suitable collars is a simple matter, and need not be described.

"It only remains to add the statement that, by this counter-die and hub process, gold, platinum, silver, or other metallic cap-

crowns, having finely-formed and solid cusps for proper occlusion and resistance to wear, can be made with little trouble and in a very short time."

After securing a well-defined occluding surface or cameo for the case in hand, it should be filled with gold plate scraps or solder of a lower carat, with a little borax. This is all held over a Bunsen burner until the small pieces of gold come to the fusing point and settle down into the depressions of the shell. More

FIG. 319.



small pieces should then be added until it is level full. The surplus gold should then be trimmed away, and a file passed several times over the surface of the solder to bring it down perfectly level and smooth. (See Figs. 320 and 321.)

Before removing the band from its position in the mouth, a small mark should be made with an excavator to indicate the center of the buccal surface, which will serve as a guide for the correct placement of the cusps. By giving the band and the

cusps a smooth surface with the file, as has been directed, it will be found that an accurate joint between them can readily be secured.

Having carefully noted the line of occlusion and marked the band to indicate the point where the center of the buccal surface of the cusps or crown-plate should be placed and soldered, the two—the band and the crown-plate—should be carefully brought together and secured, either with a few strands of small binding wire or with suitable pliers, as shown in Fig. 322. The joint should now be coated with borax dissolved in water, when it is ready for the final soldering. If solder has been used in filling the cusps, no additional solder will be needed at this time, as by simply holding the crown over the flame of a Bunsen burner as shown in Fig. 322 until the solder is seen to come to the fusing point,

FIG. 320.

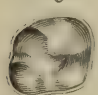
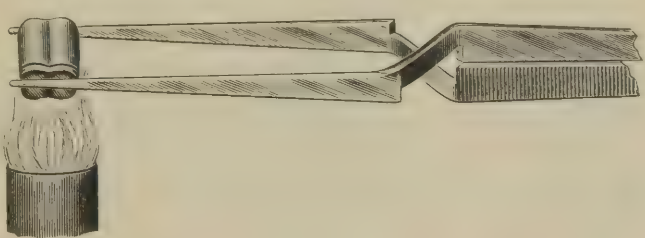


FIG. 321.

FIG. 322.



then instantly withdrawing it, the crown-plate and band will be united perfectly. If, however, gold plate has been used entirely in forming the crown-plate, a small piece of solder will be needed to unite them. The crown is then ready for the finishing processes, which consist in filing or grinding off the projecting edges of the crown-plate flush with the face of the crown, and smoothing and beveling the free edge of the band or ferrule; the crown should then be adjusted to the root and the occlusion noted. If, as is frequently the case, a little of the gold needs to be removed at one or more points, in order to have a perfect occlusion, it should be done with a small, flat-faced corundum-stone. The crown should then be removed and polished at the lathe.

"**Gold Seamless Contour Crowns.**"—The manner of con-

structing what is known upon the market as the "Evans Gold Crowns" we here present, through the courtesy of Dr. George Evans, who says:—

The artistic requirement of all-gold crown-work is, that it shall reproduce the anatomical contour of the natural teeth. This is usually accomplished by melting solder on the collar and then trimming it to the form of the crown. A preferable method is to shape the metal forming the sides of the crown by swaging. This is easily done in a crown formed in sections, but a special process is required in the construction of seamless crowns.

A contour crown can be made by placing a seamless cap on a sectional die or mandrel of the shape of the tooth, first swaging the grinding-surface on the mandrel and then stamping downward on the straight sides of the crown with a cap fitted to the shank part of the mandrel. But such a process, like many

FIG. 323.

FIG. 324.

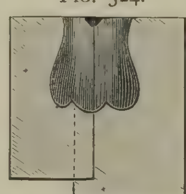
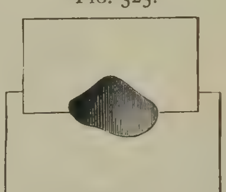


FIG. 325.



others, is too complicated to be of any use to the dental practitioner. The sectional mold method here presented is simple, practical, and general in its application.

To describe and illustrate the process, we will take one of the most difficult crowns to construct—a superior molar (Fig. 323). A natural tooth, or one made of plaster, is used as a model. From this a sectional mold is made, as illustrated in Figs. 324 and 325, in Babbitt's metal, zinc, or fusible alloy. Into the mold a cap of gold (Fig. 326) 23 to 24 carats fine, 30 to 32 gauge, is adjusted, fitting tightly the orifice of the closed mold. The mold is placed in a vise, the cap expanded to the general form of the mold by hammering into it a mass of cotton, and then swaged more in detail to the form, and with a wood point or a burnisher revolved by the dental engine burnished into every

part of the mold (Fig. 327). To facilitate the process, the mold should be frequently opened and the gold annealed. Fig. 328 represents the completed crown. These results can be secured by other styles of molds.

Another method is to form a fusible-metal die of the tooth to be crowned, and, after having stamped the grinding-surface of the crown, to reverse and swage the sides close to the die; the crown is then relieved of the core (die) by heating to the melting point of the fusible metal and pouring it out.

For practical use, a variety of molds is required, made from natural teeth of different sizes and average forms to serve in corresponding cases. The crowns can be contracted at the neck more than their size and contour call for, so that the gold will

FIG. 326.

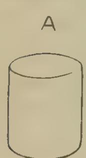


FIG. 327.

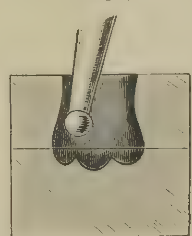
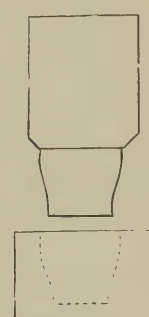


FIG. 328.

FIG. 329.



act as a tight-fitting band, which will expand to the form of the root as the crown is pressed up in the process of adjustment.

Caps of metal can be made in different sizes and kept on hand for use in this and other styles of crown-work by means of a machine which in principle is such as is used by jewelers for forming cap-shaped pieces of gold, and in factories for making copper cartridges. The gold plate, cut into circular pieces, is pressed through a steel die-plate, with punches gauged to the holes; at each punch a small portion of the gold is turned over, thus preventing its lapping or creasing. Repeated annealing of the metal is very necessary in this process.

Methods of Contouring Crowns Constructed in Sections.—In constructing a crown in sections, the collar can be

first formed on a mandrel, then placed in a mold, and burnished to the shape of the sides. The process of its adjustment to the neck of the root is then continued in the usual manner.

Another method is to stamp or burnish up the collar on a die representing the upper sections of a tooth, designated as the middle and cervical third (Fig. 329). After contouring the collar, the cap is adjusted and soldered on. With a metallic stamping plate (see page 273) these caps are quickly made.

The Selection and Adjustment of Seamless Contour Crowns.—A superior molar—one of the most difficult teeth to operate on—will serve as a typical case to illustrate this process. The crown or root is first shaped and if necessary built down with amalgam, straight, or tapering slightly on its sides toward the occluding surface.

The width of the crown required from the anterior to the posterior sides of the occluding surface is first obtained by measurement with a piece of card-board or thin copper plate, as shown at A, Fig. 330. The measurement can be taken direct from the mouth, or more conveniently from a small plaster cast made from a correct impression of the *prepared crown or root* and the two approximal teeth. This measurement can also be taken by means of tweezers with a set-screw (Fig. 331). With this measurement as a guide, the proper-sized occluding surface is readily found by comparison with the dimensions of the various crowns as shown on the printed chart of the crowns (C, Figs. 332 and 333).

FIG. 330.

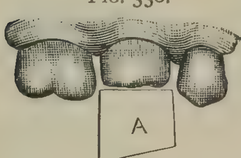
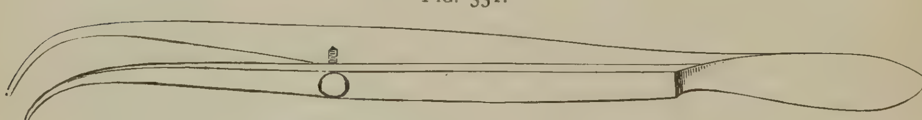


FIG. 331.



Tweezers with Set-screw to use as Calipers.

The size of the neck can be calculated by the eye, or by taking the dimensions with a piece of fine wire (Fig. 336), pressing the

wire on the surface of a piece of sheet wax, and then comparing with the impression the necks of the gold crowns.

In making a selection, it should be borne in mind that the cervix of the gold crown should preferably be smaller than larger, as it can always be easily expanded, while its contraction is difficult. It is not essential that the curve of the collar shall correspond with that of the tooth, as the gold will readily take the proper shape as the crown is adjusted.

Method of Adjusting the Crown.—1. Anneal the crown selected, and slip it over the end of the natural crown or root and gently press or work it upward—the gold of the collar will

FIG. 332.

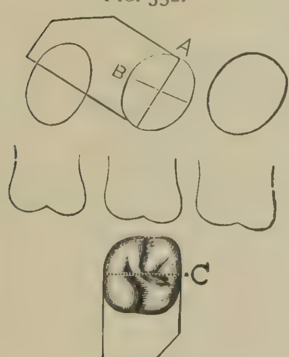


FIG. 333.

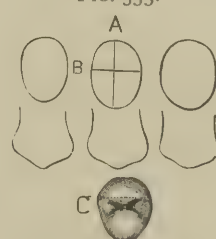
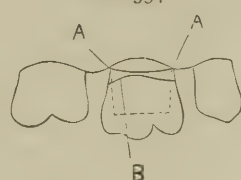


FIG. 334.



expand to the form of the root in the operation—until the edge meets the margin of the gum (A, Fig. 334).

2. Mark a line (B) on the gold parallel with the margin of the gum.

3. Remove and trim to this line (A, Fig. 337). If necessary repeat the marking and trimming until the edge meets the gum evenly.

4. Bevel the edge of the gold, readjust the crown, and press it up until the edge of the collar passes under the margin of the gum, and, if the occlusion is correct, burnish the gold to the cervix.

To Expand the Collar and Crown.—If the collar of the crown needs enlargement, it is easily and most properly accomplished with crown expanders (shown in miniature form in Fig. 338), the points of which should be introduced at first just within the edge of the neck, and the gold spread sufficiently to allow it to fit over the end of the natural crown or root, the process of

FIG. 335.

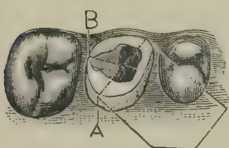


FIG. 336.

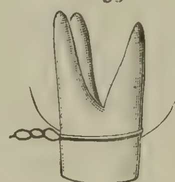


FIG. 337.

expansion being gradually continued as the crown is brought into position. By proceeding in this manner too great expansion is avoided.

If the entire crown needs enlargement, it is best done by softening a mass of gutta-percha of about the same size as the crown upon the closed ends of a pair of expanding or clamp forceps, which are heated for the purpose. The forceps points with the gutta-percha are then introduced inside the collar of the crown, which should be moistened to prevent adhesion. The gutta-percha is next withdrawn, hardened in cold water, and cut through the center between the points of the forceps. This makes practically an expanding sectional mandrel with which the crown can be enlarged according to the position in which the forceps were introduced (Fig. 339).

FIG. 338.

FIG. 339.

To expand the crown without enlarging the neck, trim off the gutta-percha on the forceps at the neck.

The naked points of an ordinary clamp forceps can sometimes be used to advantage in expanding a portion of the coronal section of the crown.

To Alter a Side.—**The contour of one or both sides can be depressed and the crown thus narrowed** by introducing the points of a crown expander or some tool that will fit loosely inside the crown, then steadying the crown with the fingers, as shown in Fig. 340, and tapping the sides to be reduced with the flat end of a riveting hammer. This is necessary when the *contour* or *the side* of a crown *presses on an adjoining tooth*, and the crown is thus prevented from coming in proper position.

To Alter the Shape of a Portion of the Collar or Side of a Crown.—Slip the crown over the point of an anvil, the end of a pair of expanders, or a small round-handled instrument held in a vise, then tap the part to be altered with the flat end of a riveting hammer to the form desired.

FIG. 340.

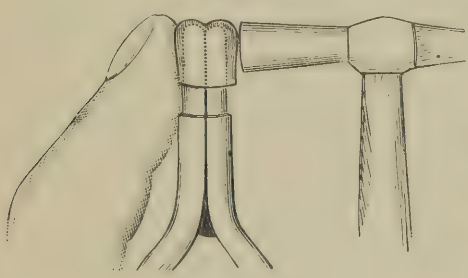


FIG. 341

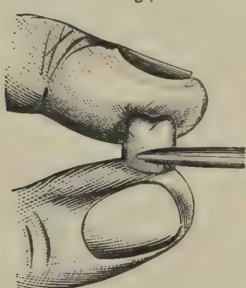
To Alter the Occluding Surface.—Before the crown is pressed up to its apparently proper position, the occlusion should be examined, and calculations carefully made to obviate any defects of articulation, which can be readily corrected at this stage by proper manipulation of the crown. Any necessary change in the form of the occluding surface can be made with the crown in position on the tooth, by means of an instrument tapped by the mallet; by removing the crown, placing it over the closed points of an expander, and tapping and burnishing the part; or by holding the crown between the thumb and forefinger with the edge of the collar resting on the side of the next finger, which when necessary can be protected with a napkin, and then tapping the gold with the point of a riveting hammer (Fig. 341).

The occluding of the antagonizing teeth on the crown by the patient will assist and complete the process of articulation.

To Contract the Neck.—Slightly bend in the edge of the gold at the neck with narrow-beaked pliers, and, holding the crown evenly and firmly between the fingers, as shown in Fig. 342, burnish the sides of the neck section inward around the entire circumference of the crown.

To Considerably Contract a Crown.—Slit the gold longitudinally at the palatal or lingual side its full length to the grinding-surface, bevel off the edge to lap under, contract the crown, readjust to the tooth, remove, place the smallest quantity of dampened fluxed solder filings in the seam *on the inside of the crown only*, and solder by holding in an alcohol flame. Then proceed with the further adjustment of the crown.

FIG. 342.



The outside line of the seam can be stoned off and polished after the crown has been fitted, and additionally soldered to strengthen the sides or grinding-surface.

Strengthening Seamless Gold Contour Crowns.—Additional strength and stiffness can be given to seamless gold crowns, when desired, in several ways. The liability of melting the gold which forms the sides of the crown in the operation has, with some, been the principal objection to their use. This, however, can be avoided.

When the crown has been properly adjusted, dampen the inner surface with a piece of wet cotton on the point of an instrument; place in the interior a quantity of fluxed solder filings (solder filings mixed with Parr's flux or pulverized vitrified borax); place the finger over the open end of the crown, invert, and shake well. A portion of the solder filings will adhere evenly all over the wet surface. The surplus is allowed to drop out by removing the finger. Then gradually and uniformly heat the crown by holding it with tweezers in an *alcohol flame* (not gas) until the solder fuses, when it will flow evenly over the surface of the gold without materially altering the general form. The

crown should be held in such a position that a full view of the interior is presented and the melting of the solder rendered visible, which will occur at a red heat.

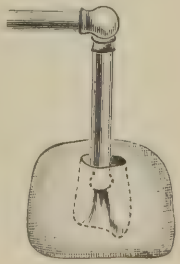
An extra quantity of the solder filings can be placed in the interior of the cusps with a spoon-shaped excavator to additionally fill or strengthen them if found necessary.

When a *Bunsen gas flame* is used instead of an alcohol flame, the grinding-surface and sides of the crown should be first coated with whiting. This is easily done by dipping the crown into a cream-like mixture of whiting just before inserting it in the flame. The moisture in the whiting should be first slowly evaporated by heating up gradually. Great care must be exercised in the use of a gas flame to avoid melting the crown. The crown should be watched, and instantly removed as soon as the solder fuses and flows.

If too much solder has been applied at any point, it can be trimmed and smoothed with corundum melted on to an old engine bur-point. Always boil the crown in acid to remove the flux. The removal of flux from the inner surface of the crown is absolutely necessary if you intend to use it in bridge-work, as solder will have to be melted on the outside.

To Repair a Gold Crown.—When a hole is cut or melted in any kind of a gold crown, place a piece of soft wax in the aperture on the outside of the crown, adapt on the inside close against the gold a piece of platinum foil, somewhat larger than the aperture, so that it will adhere to the wax. Fill the interior of the crown with investing material, and flow a little solder over the surface of the platinum and gold on the outside of the crown.

FIG. 343.

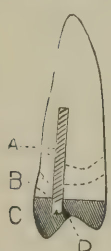


Gold seamless crowns can also be strengthened or filled with solder, or even 18- or 20-carat gold plate, by investing the outside surface in plaster and marble-dust (Fig. 343), and then with a small flame of the carbo-oxyhydrogen blowpipe, not over one-half an inch in length, introduced inside of the crown, melt and flow the solder or gold plate over any portion or even all of the surface of the gold.

The crown, if formed of gold with a thin lining of platinum, can be soldered by either method with little danger of being melted.

Supporting the Crown.—In crowning teeth with living pulps there is sufficient of the natural crown present to afford a secure foundation and attachment for the artificial crown, as is also the case with many teeth that are pulpless; but in badly broken-down crowns, or where only the root is present, a metallic pin or post should be inserted in the root, and the part built down with amalgam to a form which will afford secure support and attachment to the artificial crown and facilitate its adjustment.

FIG. 344.



In many cases the required support for the crown can be secured by means of a screw (Fig. 344). A How screw or a post of silver wire is inserted in the root-canal A (see page 208). Amalgam is then packed in the lower section of the artificial crown, C, to the line B, and into the amalgam the screw is pressed. Amalgam which has been put in a piece of chamois and the mercury pressed out with a pair of pliers until it is in the condition termed "dry" will adhere to the gold without affecting it. The amalgam is first placed in the crown slightly in excess of the amount required, and the crown adjusted, removed, and the surplus scraped out. This process is continued until the screw or the crown section of the natural tooth forms an indentation in the amalgam, which it will fit when the crown is cemented on. The vent for the escape of air and surplus cement—which should always be put in perfect-fitting crowns and afterward filled with gold or amalgam—should be in the line of the indentation in the amalgam, with which it must connect (D).

These crowns can be inserted in an easy and inexpensive manner by filling in the lower section of the crown with amalgam instead of gold, and allowing the head of the screw or the natural crown to indent the amalgam as above described, and then cementing on the crown with oxyphosphate in the usual manner.

In a case so inserted, with no antagonizing teeth, the result is the same as though the inside of the occluding surface of the

crown was filled with gold; but if antagonizing teeth are present, the gold of the crown is apt to wear through in places and expose the amalgam.

To Securely Attach a Crown.—If the tooth is short, and the occlusion of a character requiring the reduction of the collar to such a degree as to suggest insecurity when the crown is cemented, a barbed or headed pin, which will anchor in the natural crown or root, should be soldered in the center of the gold crown. This is done by passing the pin through a hole drilled in the occluding surface of the crown, which is then adjusted in the mouth, removed, invested, and the pin soldered from the outside. If the pin is tapered and fitted tightly to the hole, the soldering can be accomplished without investing, by holding the crown and pin with solder in position in an alcohol flame.

To Alter a Gold Crown to the Exact Form of any Corresponding Natural One.—In a case having nearly all the natural teeth present, in which the occluding surface and sides differ in shape from the form of the gold crown, to such an extent as to interfere with its adjustment, a die of the natural crown should be made of fusible metal (Melotte's Fusible Alloy), and with it the interior of the gold crown should be altered in shape sufficiently to receive the natural crown, by resting the occluding surface of the gold crown on a folded napkin and gently tapping the die into it.

The advantages of seamless contour crowns are, that they represent perfectly the tooth in its anatomical contour, present a uniform surface of pure gold, which preserves its color without tarnishing, and are quickly and easily adjusted. Their defects are inability to meet the requirements of abnormally-shaped roots and anomalous articulations.

Bridge-Dentures.

To the skilled dentist, well versed in crown-work, bridge-work does not present any great difficulty, inasmuch as crowns are the beginning and the end; it is practically continuous crown-work, though many of the crowns—those filling or bridging

the space where the roots have been removed—have neither collars nor posts. In constructing these teeth, the matter of cleanliness should especially be considered; where it is admissible to allow them to come in contact with the gum-tissue (as in the anterior part of the mouth), only the cervical porcelain tips should touch. The metallic backing and solder should recede, leaving self-cleansing spaces.

Some diversity of opinion exists, however, as to the advisability of permanently fixing such appliances in the mouth. Prominent among the objections urged is, that, in the event of accident to the porcelain facing of the crown, there is no sufficient remedy without detaching the entire piece, of which the teeth are a part. It is further objected that a stationary fixture of this kind in the mouth must become not only offensive from the accumulation and retention of oral débris incapable of adequate dislodgment, but a source of injury to the remaining natural teeth, which necessarily follows the prolonged retention of alimentary substances exposed to conditions so favorable to fermentation and putrefactive decomposition.

On the other hand, the writer entirely agrees with many competent, intelligent, and conscientious operators, who, from observation and experience are qualified to form a just estimate of the merits or demerits of bridge-dentures, and who bear testimony in unqualified commendation of its superior excellence *when skilfully performed under conditions that justify the operation*, and claim for it as complete exemption from the alleged objections as is obtained in the use of any other mode of replacement in similar cases.

In fact, herein, we think, lies the secret of either success or failure in connection with bridge-dentures, for it is in the construction of this class of dentures, more than any other, that unusual mechanical skill is required, and professional judgment needed for determining *where* they are admissible.

Limitations.—For the support of bridge-dentures strong, healthy roots are required, and the width of the space to be spanned must be governed by the size and strength of these points of anchorage. Whether a full upper or lower denture can be supported by four points of attachment depends upon the

relative smallness of the jaw, the size and strength of the roots and teeth, and the occlusion, the operator always being governed by the exact condition of individual cases.

Before entering upon a more general consideration of the subject, it may be helpful to give a few reflections or suggestions in the way of typical cases, as follows :—

One strong central root will support two teeth, that is, the crown and either the adjoining central or lateral. Two central roots will support the four incisors. Two strong cuspid roots alone, or with the aid of a central root, will support the six anterior teeth. A cuspid root and a strong, healthy second or third molar on the same side will support the intervening teeth. One molar or bicuspid on one side, and a bicuspid or molar on the other, with one or two central roots, will support a bridge between them. One right and one left molar, with the assistance of the two cuspid roots, when the conditions are favorable, as spoken of above, will support a bridge comprising the entire arch.

It should be remembered that the preparation of the teeth and roots for the support of a bridge is the same as in ordinary crown-work, except that the trimming of the sides and the drilling of the root-canals should be, as far as possible, *in parallel lines*, so that in the adjustment of the finished piece the crowns will move readily to their place.

STATIONARY BRIDGE-DENTURES.

Among the simpler forms of substitution which may be properly classed under the head of "bridge-work," is the one in which a single artificial crown derives support from attachments made to one or more of the adjoining natural teeth, originally by a process of cavity-filling. The original conception and practical application of such a method of supplying an edentulous space is attributed to Dr. B. J. Bing, of Paris, France, whose method of operating has since been greatly modified.

Dr. Webb's Method.—One of the earlier experimenters in this mode of replacement was the late Dr. Marshall H. Webb, who thus describes his method of operating in these cases :—

"The insertion of a crown without plate or clasps, where no

root remains, is a difficult operation, but when well performed, and the crown attached to teeth that are firm in their sockets, it is both satisfactory and permanent.

"The first such operation performed by the writer was completed February 12, 1873, and the crown now remains as firm as when inserted. The operation was performed in the following manner: After suitably forming the cavities in the proximate wall of each tooth next the space left by the loss of the one that had been extracted (unnecessarily) some years before, an impression of the parts was taken, and a plain porcelain crown was selected, fitted to place, and backed with gold plate (18 k.). A portion of the backing extended about one and a half lines from each side of the crown for insertion in the cavities prepared in the adjoining teeth, and to these parts a gold wire was soldered to fit into the pulp-chamber of the central and lateral incisors. A small gold plate was then formed to fit upon the gum, covering as much space as was taken up by the neck of the natural tooth. The backing was riveted to the pins in the porcelain, and this placed in position, and while the whole rested on the small plate upon the gum, the backing and plate were so secured by wax that they could be removed intact, and, after being placed in a matrix, soldered. Each extended side of the backing and the surface of the wire was barbed with an engraver's bossing tool, so that the gold foil would the better secure the crown when filled into every part.

"The porcelain, with the gold attachments, being ready for insertion, a piece of light, medium rubber-dam was put in place on two teeth each side of the space to be filled, and over the gum upon which the crown was to rest. (The rubber takes up but little space, and this is more than compensated for, when the ligature—waxed floss-silk—is pressed to or near the neck of each adjoining tooth.) Oxychlorid of zinc was then placed in the pulp-chamber of the central incisors and the crown at once pressed to place. When the cement had hardened sufficiently to safely admit of further progress in the work, a portion of it was cut away from around the wire so as to make proper anchorage for the gold. Small pieces of light cohesive gold foil were then impacted around part of the wire and that portion of the plate

extending into the cavities, and the crown was thus secured. The porcelain and gold attachments as prepared for insertion, and the crown in position, are illustrated in Fig. 345.

"The cavity in the central incisor was extended to the cutting edge of the tooth, that access might be had to the wire and both sides of the plate; foil could not otherwise have been put in place, unless a portion of the labial margin of enamel were cut away, and this would have been objectionable because of the exposure of gold. A small part of the labial instead of the cutting edge of the enamel of the lateral was removed, for the reason that there is not such a body of tissue as to safely allow it to be cut away to the same extent as in a central incisor. The

FIG. 345.

margin of enamel was so formed, and the foil so inserted and finished, however, that, though the gold can be seen, it is not conspicuous.

"While the operation just described has thus far proved successful, yet there is a possibility of the porcelain being broken from the platinum pins which hold it to the gold plate. To avoid such an accident a groove should be cut on each side, and along the cutting edge of the porcelain (Fig. 346, *b*), that gold foil may be impacted into it, after a heavy backing of gold plate and the wire have been fixed in place and soldered. When the groove has been cut in the porcelain with a fine-edged corundum disk, one with an edge of the diameter of the gold wire selected for

the case should be used to make a groove across the porcelain between the pins (Fig. 346, *a*), into which the wire to connect the artificial crown with the natural teeth is to be placed (Fig. 346, *b*), either beneath the plate or so that the edges of the latter may be joined to it, as the necessities of the case may require.

"A starting-point should be made either between the gold backing and porcelain, or between this and the wire, and the latter firmly fixed in a hand vise while the gold foil is being impacted with the electro-magnetic mallet. When the gold is properly and solidly placed in the groove and over the backing and wire, it not only aids in securing the porcelain, but the contour of the crown can be nicely filled out, and the operation made durable and beautiful (Fig. 347).

"The surface of the gold placed along the base of the crown

FIG. 346.

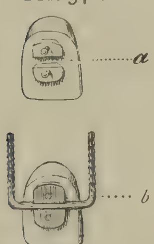


FIG. 347.

to the edge of the porcelain, and which is to rest against the gum, together with the palatal portion, ought to be properly formed and finished before the crown is put in place, and this should be done in the manner before described. There should be a little space between the wire and cervical wall in each tooth to which the crown is to be attached, and narrow pieces of light gold foil carefully placed in this part, between the wire and enamel, with small curved instruments and the aid of the mallet; the surface of the gold at this part at least should be smoothly finished with very narrow ($\frac{1}{16}$ in.) strips of fine emery-cloth before the rubber-dam is removed.

"In cases where the pulp is living in one or both of the teeth to which an artificial crown is to be attached, the heavy gold plate or the wire must be so arranged as to fit as accurately and

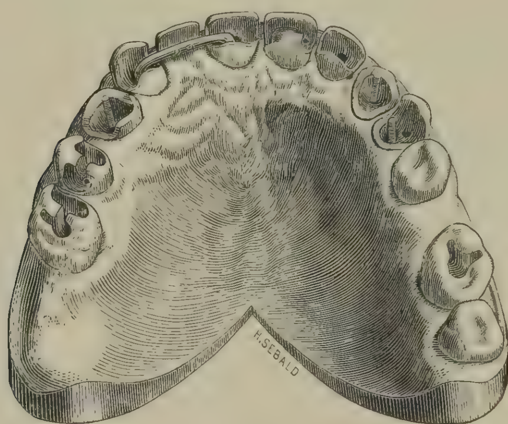
to be made as secure as possible in the cavities prepared for them. In some cases, where the form of the cavity admits of it, it is better to adjust and solder a small gold plate to the end of and at right angles with the wire attached to the crown. This plate should be so formed and beveled that gold foil can be solidly placed over the surface of it next to the artificial crown, and into the groove made around the cavity in the dentine along the boundary line between this tissue and the enamel. When all is in readiness for the operation, oxychlorid of zinc should be placed in each cavity and the crown immediately put in place, and very carefully held there till the cement has so crystallized as to secure the ends of the wire and plate ; about an hour is necessary to perfect such crystallization as to safely admit of the preparation for and the packing of the gold foil. The oxychlorid of zinc should be left between the little plate or end of the wire and bottom of the cavity, and all parts where gold cannot be well placed; this preparation also protects the dentinal fibers from thermal changes.

"One of the most satisfactory operations the writer ever performed was the insertion of a crown where a cuspid root had been extracted (unnecessarily), and the lady subjected to the wearing of a gold plate for some time. This crown was prepared and the contour filled out with foil as described (and as illustrated in Fig. 347), but gold wire, No. 13, was attached to and built in with the porcelain, placed into the pulp-chamber of the adjoining lateral incisor (which had been filled), and this same wire extended from the anterior to near the posterior proximate surface of the first bicuspid tooth, the pulp of which remained in normal condition. The crown was placed in position with oxychlorid of zinc, and cohesive gold foil was then impacted with the electro-magnetic mallet around a portion of the wire in the root and into the cavity in the crown of the incisor, also into the cavity in each proximate wall of the bicuspid tooth, as well as around and over the wire, joining the two fillings through the enlarged fissure.

"The most extensive operation of attaching a crown to adjoining teeth was performed by the writer before the Pennsylvania State Dental Society, at Delaware Water Gap, in July, 1879. In

this case disintegration had taken place in many of the teeth, and cavities of decay had been prepared and filled from time to time. The teeth were abraded and the dentine was exposed along the entire cutting edge of each tooth that occluded with another. The right upper lateral incisor had been lost twelve years before. The crown of the left cuspid tooth was missing, and but a small portion of the enamel and dentine of the first bicuspid upon either side remained. These last were, of course, pulpless, as also were the right cuspid and central and left lateral incisor teeth, and the pulp-chamber of each of these had been filled. All the operations made necessary by the abrasion and fracture of

FIG. 348.



enamel from time to time, and because of imperfection in the fillings before introduced, were performed previous to the insertion of the crown in the space left by the loss of the lateral incisor, and, as this crown and each cavity and pulp-chamber was prepared for the gold, all appeared as here illustrated (Fig. 348).*

"Gold wire (No. 13), with a sharp thread cut upon it, was screwed into the dentine, and, at the same time, all the interstices between the tissue and the gold were filled with oxychlorid of

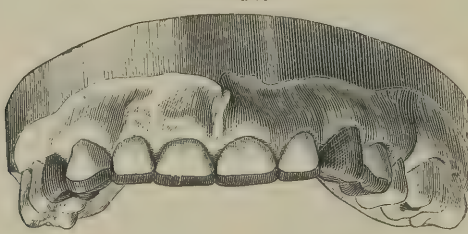
* The cut (Fig. 348) illustrates the case well, though there are parts and grooves in which to anchor the gold, that are not distinctly shown.—M. H. W.

zinc. When crystallization had taken place, some of the cement and dentine was removed from around the wire with a small bur, and a groove was cut in the dentine near the margin of the root so as to secure proper and sufficient anchorage for gold; cohesive foil (principally No. 30) was impacted into these parts, and the entire contour of the crown was restored with the electro-magnetic mallet. This crown was not faced with porcelain, because the teeth of the gentleman for whom these operations were performed are but slightly exposed to view; and then, too, the gold had to be placed over the enamel to support and protect it along the cutting edges of all the incisor, the cuspid and bicuspid teeth. A gold screw was placed in the pulp-chamber and extended into the crown of each bicuspid tooth (Fig. 348). The apical foramen of each pulpless tooth was closed, and the whole of each pulp chamber into which a wire was not placed was filled with gold. With a properly adjusted electro-magnetic mallet, carefully guided, and operated with a full current of electricity from a freshly-charged four-cell Bunsen battery, the contour of each crown was restored with gold, made solid and perfect throughout; the foil was placed in the same manner over the finely prepared margins of enamel, which were not marred in the least (Fig. 349).

"The lower incisor teeth had so changed after the loss of the upper lateral that they almost closed upon the gum. This was partly owing to the abrasion of the remaining teeth, and in part due to the lower incisors gradually rising in the alveolar process. Because of such occlusions of the teeth a porcelain crown (plain 'plate tooth') with 'cross-pins' was used, and fitted and soldered to the gold wire, there being no space for a backing of plate. When the wire was prepared, the porcelain grooved and fitted to it, and ready for the placing on of the gold foil, the whole appeared as illustrated (Fig. 348), the wire extending into each root about four lines. The cutting of the porcelain was removed to the same extent as that of the abraded and prepared incisors, so as to present the same appearance and have the gold support and protect the remaining part. The wire of the crown was held in a hand-vise, while cohesive gold foil was placed solidly in the grooves, around the wire, over the cutting edge of the porce-

lain, and the entire contour restored with the electro-magnetic mallet. During the final fitting of the crown, it was made to so rest against the gum, that the blood was pressed from the capillaries of the part. When ready for insertion, a medium rubber-dam was applied to two teeth each side of and across the space which was to receive the crown; small barbs were made all around the wire with a sharp knife, and oxychlorid of zinc was then placed in the pulp-chamber of the central incisor and cuspid, and the crown at once pressed to place. After it had been in position an hour, to allow of complete crystallization of the cement, portions of this and of the dentine were removed with a small bur so as to better secure the crown and obtain anchorage for the gold foil then to be put in place around the wire, into each cavity, and over the prepared margins of the

FIG. 349.



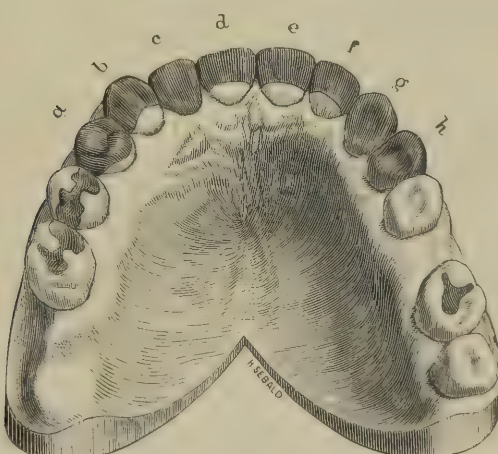
enamel. Principally No. 30 gold (one-quarter ounce cohesive foil) was used in this case, and all was impacted with the electro-magnetic mallet, except a few pieces of light foil placed in the space between the wire and cervical wall, and even these pieces were gone over with this very valuable instrument after they were in place. With this and all the operations completed, the case appears as here illustrated (Fig. 349).

"All those who have the ability and who will work earnestly and conscientiously to properly perform the various operations described, and do their very best in every case, can so manage their practice as not to make it necessary for any of the patients they have charge of to wear artificial teeth mounted upon plates."

Dr. Webb's method of operating in these cases was, to some extent, subsequently modified as follows:—

"The method, modified and followed by the writer, since performing his first operation, is quite different from the mode adopted in inserting the first crown, which was prepared somewhat according to Dr. Bing's plan, and, though the work is more difficult, yet the improved crown is stronger and more complete, cleanly, and beautiful than when gold plate is simply riveted and soldered to the porcelain. It was to avoid such an accident as the breaking of the porcelain from the pins

FIG. 350.



a, *b*, *d*, *f*, *g*, and *h*. Pulpless teeth. *g*. Whole crown restored with gold. *a*, *f*, and *h*. Almost entire gold crowns. The teeth, *b* and *d*, support the gold crown faced with porcelain, *c*, and fully one-fourth of the crown of each of these is restored with gold, as is also that of *e*, the pulp of which is living.

that the writer modified the method of preparing and inserting crowns. Among the changes made were those of making a groove (though not cutting it too deeply) in each side and along the cutting edge of the porcelain, and placing gold foil solidly in the groove and slightly over the cutting edge, to make the porcelain more secure than when the platinum pins alone hold it, and to protect the edge from the occlusion of the lower teeth; also, to build the crown into the approximal surfaces only. After the wire has been fitted to the adjoining tooth or

teeth, or properly placed in a root, and a heavy but rather narrow backing of gold plate has been riveted to the porcelain, and the parts are fixed together and soldered, the greater part of the preparation of a crown which remains to be made, and the whole of the building of gold foil about it, is done out of the mouth at whatever time may best suit the operator; but the work requires care, and must be skilfully and well done. A starting-point should be made either between the gold backing and porcelain or between this and the wire, and the latter must be firmly fixed in a hand-vise while the gold foil is being put in place and made compact with the electro-magnetic mallet. All crowns should be prepared and finished in the manner described, with such change or additional work as is necessary to place them on roots, or to attach them to single or to the two adjoining teeth where roots are missing.

"Methods have been devised or adopted with the object of lessening the time necessary to perform such operations, and making them easy and cheap, by the use of amalgam or some other plastic material; but sufficient time must be taken, excellent judgment and ability are required, and the use of gold is necessary for the doing of really fine, beautiful, and permanent work.

"When a crown is to be attached to one tooth alone, the operation is not likely to be successful (excepting where a bicuspid crown is built into a molar tooth), unless the tooth which is to support the crown be a pulpless one, and then such an operation can be made both durable and beautiful. To secure sufficient anchorage for the insertion of a crown in such a manner, therefore, it may sometimes be necessary to destroy a pulp; but this ought to be the last resort, and should be done only when calcification of the enamel and dentine is complete or apparently so. The end, if well attained, justifies the destruction of a pulp for the insertion of a crown, mainly because of the beneficial results which follow. These are the longer preservation of the remaining teeth, the gums, and the alveolar process in normal condition, or the prevention of the absorption of the hard as well as the soft tissues under, and because of the pressure of, plates—this loosening and loss of teeth sometimes occurring years before

there is likely to be such solution of the lime-salts of the maxillary border and recession of the gum.

"Where a crown is to be built on to one tooth only, a gold wire no lighter than No. 12 should be used. It should be fitted as far up the root as it is safe to enlarge the pulp-chamber for it; but the drilling may be properly done only after every part of the pulp has been removed and the apical foramen has been carefully closed with small, narrow pieces of light gold foil, which must not be put in place so long as there is any irritation about the end of the root.

"In the case here illustrated (Fig. 351), the wire is fitted in the root and bent to receive the crown, and the cavity is nearly prepared for the filling in of gold. The cuspid (as well as the other teeth remaining in the mouth) became so abraded as to expose the dentine, so that the margins of enamel had to be prepared for the placing of gold over them, and when the crown was built in place, they were carefully covered with and are thus protected by the solid metal. After the porcelain part of the crown of the lateral incisor had been fitted to the model and soldered to the wire—this portion of the wire should be flattened somewhat in some cases—the groove was made around the porcelain; the foil was solidly built in place, and finished in the manner hereinbefore described, the crown was then inserted and the contour of the cuspid tooth was restored with gold. The root of the left central incisor remains, and the crown which is fitted upon it is prepared for the building on of gold foil; after which it will be ready for insertion.* When this crown is put in place, the gold wire is to be surrounded with gutta-percha; but little of which is, or should be, needed in the pulp-chamber, because of the close fitting of the wire in and of the crown upon the root. During this preparation, a plain 'pivot' crown is kept upon the root, held by wood and gutta-percha.

FIG. 351.

* The groove is not distinctly shown in the cut (Fig. 351).—M. H. W.

"When the lateral incisor crown, in the case illustrated, was ready for insertion, and the gold at the base, which was to rest upon the gum, had been nicely fitted to it, and the whole of the gold was smoothly finished, a good-sized piece of medium rubber-dam was applied to the teeth (the cuspid and the central and lateral incisors) on each side of the space to be filled, and arranged so as to cover the gum and the root between these teeth. The crown was made to so rest upon the gum as to press the blood from the capillaries of the part, and thus prevent particles of food from getting under it. (While the thickness of the rubber-dam might, to some extent, prevent the placing of such a crown against the gum as firmly as it should be pressed, yet this thickness is compensated for by the pressing up of the gum when the floss-silk ligatures are placed about the neck of each adjoining tooth.) After all this had been done, and fine barbs were cut around the gold wire with a sharp knife-blade, oxychlorid of zinc was placed in the pulp-chamber of the cuspid tooth, and, while the cement was still plastic, the crown was at once pressed to place, and held there for a few moments.

"After the cement had hardened sufficiently to safely admit of it, it was cut away from around the wire at such parts as would make proper anchorage for the gold. There was, and in every case should be, a little space left between the wire and cervical wall to be filled with gold for the protection of the enamel at this part. Narrow pieces of light cohesive foil were first placed in this space with small, suitably curved instruments, and afterwards solidified with the mallet; after which a little larger (though still narrow) and heavier (none over No. 32) pieces of folded foil were used for placing around and about the wire in the root, filling the cavity, restoring the contour, covering and protecting the prepared margins of enamel, each piece of the gold being thoroughly cohesive and made compact with the electro-magnetic mallet. The surface of the gold placed around the wire between it and the cervical wall, as well as all that part near the gum, was smoothly finished with small files and very narrow ($\frac{1}{16}$-inch wide) strips of emery cloth before the removal of the rubber-dam; after which the remainder of the gold was made smooth and so trimmed down as to be

sure of the proper occlusion of the teeth. The crown attached to the cuspid tooth was made just short enough to be free from the striking of the lower teeth. The operation was finished at another time with Hindostan stones, together with pumice upon fine wood made into suitable shape.

"When a crown can be securely attached to one instead of two teeth, the time of building-in is lessened about one-half. The slight movement which takes place in the socket of the tooth supporting the crown is not so interfered with as when two teeth are fixed together by the gold wire holding the porcelain. If it should afterwards become necessary to perform operations upon the adjoining teeth, the rubber-dam can as readily be applied as before attaching the crown."

Dr. Darby's Method.—Professor E. T. Darby, in commenting on the method just described, says: "Dr. B. J. Bing was the first to call my attention to a method of building one tooth into the adjoining teeth by means of gold wires running from the artificial into the natural teeth. I have never seen any of Dr. Bing's operations, but Dr. Marshall H. Webb has called my attention to one or more in the mouths of his patients, which have done good service for years. I also have in my own practice several which have proved most satisfactory.

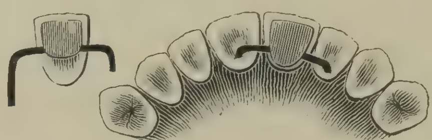
"The cuts, Figs. 352 and 353, represent two cases where artificial crowns have received their support from the adjoining teeth. It is desirable to have a pulpless tooth for a neighbor, though I question if one would be justified in devitalizing a pulp to secure this end. In the cases presented, a piece of gold wire was soldered to the backing of the porcelain tooth, and allowed to extend well up the pulp-canal of one of the adjoining teeth. After it had been nicely fitted to its place, the rubber-dam was applied and drawn tightly over the gum between the two natural teeth; the canal of the devitalized tooth was then filled with oxychlorid of zinc and the tooth with its gold support pressed into position. When the cement had hardened, the bulk of it was cut out and the space filled thoroughly with gold. The other end of the bar was packed around with gold foil, and the cavity of decay or cavity of convenience was filled in the ordinary way.

"It is always better to take an impression of the space and

adjoining teeth at the outset, and then do the major part of the work in the laboratory. The gold wire which enters the root can be bent or shaped with the pliers when the crown is adjusted for final insertion.

"I would not be understood as saying that these operations can only be performed successfully where there is a devitalized tooth for a neighbor; on the contrary, I have seen teeth inserted

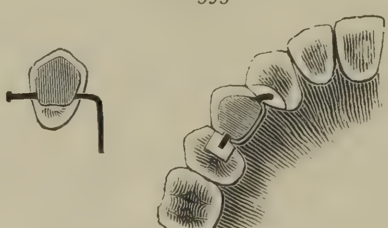
FIG. 352.



in this way where both teeth were living, but the support which is to be derived from the long right angle of gold in the root is certainly a great security against accident, adding, as it must, much strength to the operation."

The Plate and Pin Bridge.—Professor Wilbur F. Litch has greatly improved and simplified the method of attaching a single crown to the adjoining teeth in the class of cases under consideration. The following is his description of the process:—

FIG. 353.



"Fig. 354 represents a typical case, in which a lateral incisor (crown and root) has been lost, the cuspid and front incisor, fully vitalized, and without approximal carious cavities, remaining in position.

"1. Take in plaster an accurate impression of the cuspid and incisor and the interspace. From this obtain a plaster model of the parts.

"2. Make from pure gold, rolled to the thinness of 26, standard gauge, base-plates, to be carefully adjusted to the palato-approximal surfaces of the cuspid and incisor. These can be made by swaging on dies and counter-dies obtained from the model, but more conveniently by bending the gold into shape upon the plaster model and pressing and burnishing it into perfect adaptation upon the natural teeth.

"3. Select a plain plate porcelain tooth of suitable length, shape, and shade, and wide enough to fit easily into the interspace. Let the neck of the tooth rest lightly upon the gum.

"4. With pure gold or platinum make a backing for the porcelain tooth.

"5. Place the tooth thus prepared and the base-plates already made upon the cast, and accurately adjust the approximal edges

FIG. 354.

of the base-plates to the backing of the porcelain tooth *in situ* upon the cast.

"6. When this adjustment is made, cement together the base-plates and backing with a brittle, resinous cement (resin, two parts; wax, one part; or sealing-wax will answer), and before the cement has fully hardened remove from the cast to position in the mouth, perfecting the final adjustment there. By this method much greater accuracy of adaptation is obtained, as the lines of length, width, and contour are too fine to be reproduced with absolute fidelity in a plaster model. In this part of the process too much care cannot be taken to have each piece of the appliance fitted with absolute accuracy to the surface for which it is designed. When this has been accomplished, throw upon the yet more or less plastic cement a stream of ice-cold water from an office syringe; this renders the cement perfectly brittle

and incapable of bending. Immediately remove from the mouth and invest in a mixture of equal parts of marble dust and plaster-of-Paris.

"7. After the investment has firmly set, solder the base-plates to the backing, and the backing to the platinum pins of the porcelain tooth, using as a solder 20-carat gold. Thus joined, the appliance will present the appearance shown in Fig. 358—A representing the base-plate for the cuspid; B, the base-plate for the incisor; C, the porcelain tooth with its platinum backing; D, the points of union between the base-plates and backing. At these points the greatest strength is required, and it is important that here a large amount of the solder should be placed. The porcelain tooth being usually thinner than the natural teeth, there is nearly always an angle or depression at the points indicated, in which the thickness of the gold can be considerably increased without interfering with occlusion.

"8. For the purpose of attaching the denture as thus far constructed, drill a small cylindrical opening through the palatal surface of the enamel of the cuspid and incisor respectively. These openings should usually be placed about as indicated in Fig. 357, at C. D. Sometimes, owing to a close occlusion, or to the contour of the tooth, it is desirable that they should be located a trifle nearer the neck of the tooth. Each opening should be well undercut, but must not encroach upon the dentine far enough to endanger the pulp. In size the openings need not be larger than will admit a platinum pinhead, in diameter corresponding to 13, standard gauge, with a shank of 18, standard gauge. Into each of these openings must be fitted a platinum pin of the size indicated. The head of each pin must be made thin and perfectly flat both upon its upper and under surfaces.

"9. In each of the base-plates make an opening corresponding in position to those in the natural teeth. Pass through these openings and cement in them the free ends of the platinum pins. While the cement is yet plastic, place the denture in position in the mouth, carefully pressing the pin-heads into the openings made for them and burnishing the base-plates into perfect contact with the palatal surfaces of the teeth; chill the cement, remove and invest as before, and with 20-carat gold solder the pins to

the base-plates, flowing upon them and the backing as much of the solder as may be necessary to give them the desired thickness and rigidity ; the amount admissible largely depending upon the nature of the occlusion, a central thickness of about 21, standard gauge, being all that is really requisite for strength, while the edges can be made much thinner.

" Fig. 355 represents the appliance without the pin. A is the

FIG. 355.

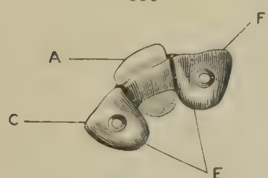


FIG. 356.

porcelain tooth and backing ; E, the base-plates ; C and F, the openings for the pins.

" Fig. 356 represents the appliance completed with the pins in position.

" Fig. 357 represents the natural teeth and interspace B, with openings for retaining-pins, C D.

FIG. 357.

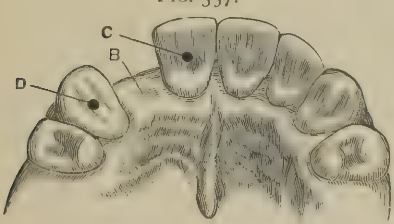
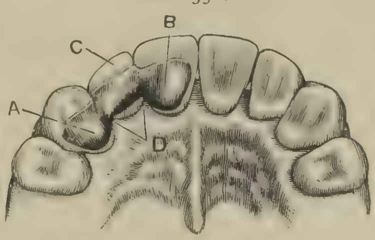


FIG. 358.



" Fig. 358, already described, represents the appearance presented when the bridge is cemented in position.

" *To Attach the Bridge.*—To attach the bridge the best attainable oxyphosphate cement should be used. It is desirable that it should set slowly. Thoroughly dry the teeth and denture ; mix the cement to as thick a consistency as is compatible with perfect plasticity. A thick, viscid, semi-fluid mass is what is

required. With suitable instruments, swiftly but carefully place the cement around the head and shank of each platinum pin, and also in the openings in the natural teeth. This care is necessary in order to exclude all the air-bubbles and thoroughly engage the pin-heads in the cement. They furnish ample retaining surface, but none to spare. In packing the cement around the pins, the under surface of the base-plates should at the same time be covered.

"The above details being perfected, the denture is at once carried to position, and with broad-pointed, serrated instruments pressed firmly into place, the excess of cement, if of the proper consistency, freely oozing at all margins.

"Too much care cannot be exercised in the cementing process. As every second of time is of value, all instruments required must be selected and conveniently placed before the oxyphosphate is mixed. To secure the most rapid, and at the same time thorough, admixture of the phosphoric acid and zinc oxid, a thick plate-glass slab, four inches square, with a flat (not a concave) surface should be used. The spatula should be of steel, thin and elastic, and six-tenths of an inch wide. With these implements the whole mass of cement, acid, and oxid can almost instantly be brought into union, the spatula being used as a muller. When a narrow and rigid spatula is used in mixing any considerable amount of oxyphosphate, the process can be accomplished only in detail, portion by portion, much valuable time being thus lost, during which the setting process is every moment hastening to its completion and rendering the cement unfit for use in this or any other form of bridge-work. A large excess of acid will, of course, make a thinner and more slowly-setting mass, but a cement thus mixed is deficient in strength and too unstable to give good results.

"A very troublesome obstacle to success in the use of the oxyphosphate cements will often be found in the temperature of the air, an elevated temperature so hastening those chemical changes upon which the hardening of these cements depends as to render their use almost impracticable. This difficulty is likely to occur only in the hotter seasons of the year, and can readily be overcome by placing the mixing-slab, as well as the

acid and oxid bottles, in cold water until their temperature has been considerably reduced.

"During severe winter weather too low a temperature also gives trouble, the acid and oxid, even when the former is in some excess, forming a powdery mass utterly unworkable, but which melts down into an almost fluid condition when brought into contact with the warmth of a tooth *in situ*. A temperature between 60° and 65° F. secures the best results in mixing oxyphosphate cements.

"*Application to Pulpless Teeth.*—In the above description the vitality of the cuspid and incisor has been assumed; but, as can readily be understood, the pin and plate bridge can be even more readily and securely placed when one or both pulps are devitalized, for the reason that, the pulp-chamber being empty, the pin-holes in that tooth can be made as much larger and deeper as may be deemed desirable, the size of the pin being, of course, correspondingly increased. In a devitalized tooth, too, the base-plate can be sunk into the palatine surfaces when they interfere with occlusion, as sometimes happens when the antagonism of the lower teeth is very close and the overlap is considerable.

"Ordinarily, however, such interference is inconsiderable, and the difficulty can always be overcome either in devitalized teeth by the expedient just suggested, or by carrying the base-plates as far away from the cutting-edge as practicable, at the same time making them at the point of contact as thin as is consistent with strength; finally, if necessary, removing a slight portion of the cutting-edge of the occluding lower tooth.

"As experience with this as well as other forms of bridge-work has fully demonstrated, a slight mutilation of a natural tooth is far less destructive in its ultimate results than is the wearing of partial plates, in the use of which pressure falls upon the gum tissue, with the ultimate effect of stripping it from around the necks of the natural teeth, thus denuding them of that protective covering, and exposing them to the ravages of decay, and it may be safely affirmed that in all applicable cases the pin and plate bridge accomplishes its purpose with the minimum of injury to the natural organs.

"The small size of the retaining-pins may excite doubts as to

the strength of the denture; but pins smaller in size are constantly used for attaching porcelain teeth to plates, and in the upper incisors these pins are much less advantageously placed for resistance to pressure than are those embedded in the natural teeth in the process above described.

"The weakest point in the bridge is not the pins, but the cement; this, while not so strong as the fused porcelain which surrounds the pins in artificial teeth, is, as experience has demonstrated, just strong enough to resist all ordinary wear and tear, without being so intractable as to render the removal of the denture for purposes of repair a practical impossibility by any method short of its destruction.

"Even with a good oxyphosphate cement, the work of removal is one of no slight difficulty, and requires the exercise of so considerable an amount of force that no one who has had occasion to perform that operation will question the security of any well-constructed specimen of this form of bridge. During an experience of some seven or eight years in their use, the writer has had but one or two cases in which the appliance became loosened, and only one in which it was detached outright. In the latter case the bridge (constructed with the natural tooth of the wearer instead of a porcelain substitute) had been firmly in position for more than a year, when the sudden wrench consequent upon biting into a very hard peach detached it. Being immediately replaced, it has since then (some two years ago) done good service. In such cases it is usually advisable to slightly deepen the undercuts in the pin-holes before replacing.

"**Repairing.**—As in all other forms of bridge-work in which porcelain teeth are used, the accident most likely to happen is the fracture of this brittle material. As the bridge does not yield under pressure as does a detached plate resting upon the compressible gum-tissue, this form of breakage is one to which bridge-work is more than usually liable. For the pin and plate bridge the least difficult method of repair is to separate the tooth and backing from the base-plates by means of a watch-spring saw, and then force off the base-plates singly, this being much more easily accomplished than their removal when united to the

backing. Another tooth is then selected, fitted, backed, and soldered as before.

"As a rule, the writer has confined the use of this form of bridge to cases in which only a single incisor is missing, but he has successfully attached a front and lateral incisor to a cuspid and the remaining front incisor. When an unusual strain is to be expected, the retaining-pins and pin-holes should, when practicable, be made correspondingly large, or two smaller pins may be anchored in one tooth, which latter plan gives very great resisting power and renders removal in the highest degree difficult and laborious.

"**Porcelain Tips.**—Figs. 359, 360, and 361 show how the pin and plate process may be utilized for the attachment of porcelain tips for broken or decayed incisors when the appearance

FIG. 359.

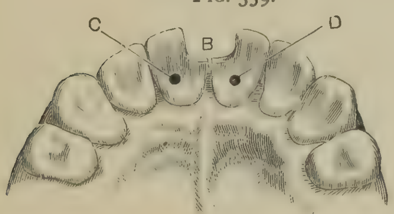


FIG. 360.

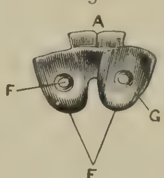


FIG. 361.

of gold fillings is obnoxious to the patient. A represents the porcelain tips; B, the space to be filled by them; C and D, the opening for retaining-pins; F and G, openings in the base-plates (E) for the pins. Fig. 361 shows the appliance with pins attached."

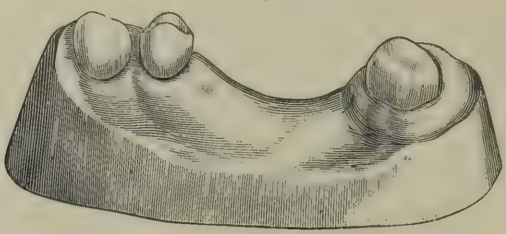
The following are descriptions of methods of replacement known as "Bridge-Work" proper, which is but an extension or amplification of the principles involved in the construction and application of the pieces just considered.

Dr. Dexter, in defining this method of substitution, says:—

"The main principles of bridging are, broadly, to permanently place artificial teeth between remaining natural teeth and roots in such manner that the porcelain substitutes shall fill the spaces made vacant by nature, while resting upon and being held in place by the natural teeth; the porcelain teeth, in the older

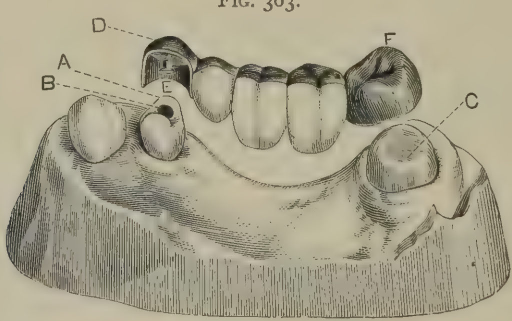
methods, resting with more or less pressure upon the gum, and in later methods being raised quite clear of the gum and supported by the natural teeth or roots in the same manner that a bridge truss or floor rests upon its piers—hence the name given the operation."

FIG. 362.



Under this head may properly be classed a process of replacement described by Prof. Litch in connection with the "pin and plate attachments" as a means of support for single front teeth, a method of attachment which, he says, although chiefly applicable to the incisors, may be combined with crown or bar bridges for molars and bicuspids. The following descriptions by Prof. Litch relate to a case in illustration of the special method of attachment spoken of:—

FIG. 363.



"Fig. 362 represents a practical case in which the upper third molar and first bicuspid (both without antagonizing teeth) were utilized for the attachment of a bridge made of gold crowns with porcelain facings, to supply the loss of the intervening teeth.

"Fig. 363 represents the case as prepared for the bridge. A,

the inner cusp of the bicuspid cut down to allow the placing of a sufficiently thick crown-plate; B, a cylindrical undercut opening between the cusps for a retaining-pin; C, the third molar made uniform in size from neck to grinding surface, the latter also being considerably retrenched; D, the crown-plate of a partial cap, made of pure gold, soldered with 20-carat gold, and so constructed as to cover every portion of the tooth except its buccal surface, the free edge passing up under the gum; E, a retaining-pin adapted to the opening B; F, the gold cap for the molar.

"Fig. 364 represents the bridge anchored in position with oxyphosphate cement.

"In the above case it will be observed that there is a considerable space between the bicuspid and cuspid. This made it readily

Fig. 364.

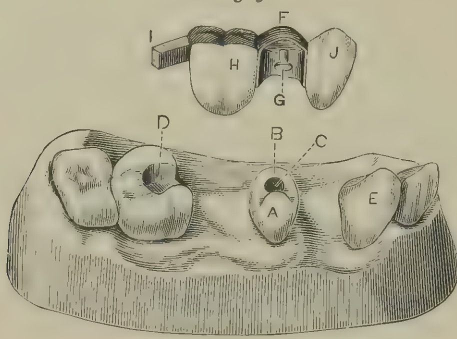
practicable to give so considerable a thickness to the mesial wall of the partial cap as to hold it securely against the side of the tooth. Had the space been less, contact with the cuspid would have afforded the desired security.

"Fig. 365 represents another case in which a bridge was attached by a bar, partial cap, and retaining-pin. A is an upper second bicuspid (without antagonist); B, its inner cusp cut down; C, opening for retaining-pin; D, second molar, with slot for bar; E, cuspid; F represents the partial facing; G, the retaining-pin; H, a molar crown of gold, with porcelain front; I, a platinum bar attached to the crown (H) and made to fit into a slot (at D); J, a plain plate cuspid, heavily backed and strongly soldered to the partial cap, but left without attachment to or contact with the cuspid.

"Fig. 366 shows the bridge anchored in position.

"This case, after two years of wear, is still in perfect condition and doing good service. As it was possible to keep the gold attachments, backings, etc., out of sight, the appearance presented is very natural.

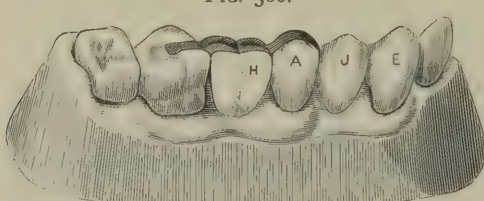
Fig. 365.



"The bridge shown in Fig. 364 has been in use but a few months.

"The absence of antagonizing teeth for the bicuspids in each of these cases was a favorable condition, as a considerable thickness could be given to the crown-plate without any interference with occlusion. When the conditions are not so favorable, cutting down the inner cusp to the required extent and sinking the

Fig. 366.



opening for the retaining-pin to the necessary depth are processes certainly to be, as a rule, preferred to the entire removal of the crown for the purpose of ferruling the root for the mounting of a crown of gold and porcelain—a procedure, however, not by any means to be indiscriminately denounced, for in many cases it is in the highest degree advisable.

" There is this fact to be considered in regard to the use of the partial caps here figured—that many patients can be induced to consent to their employment who would refuse to submit to more radical measures, and thus, even when the latter would be advisable, the former may be employed as a compromise, or even as a temporary expedient. Having once tested the advantage of a well-fitting bridge, the wearer is much more likely to consent to whatever measures are necessary to give it security and permanence.

" In the cases figured, however, as well as in analogous cases, these qualities seem to be amply secured. In every instance in which the removal of a pin and plate bridge has been necessary, the film of oxyphosphate cement has been found intact, and the surface of the tooth upon which it rested perfectly protected from decay. The only exceptions to this rule have been the very few cases in which one or the other of the retaining-pins has become loosened, the bridge being for some weeks still worn in the loosened condition. Under such circumstances the cement will, of course, become detached and wash out, admitting food and secretions ; but so long as the appliance remains immobile—and that is its normal state—the cement rests undisturbed. It need hardly be claimed that its durability is without limit, although under a metallic covering it appears to be practically so ; but under the conditions represented in the processes as above described, it is certainly good for many years of satisfactory service, and when it fails, through chemical abrasion, it will fail first at the free margins, where defects are most easily seen and remedied."

Dr. Register's Method.—The following is a condensed account, by Dr. Dexter, of a method of bridging devised by Dr. H. C. Register, one of the earliest experimenters in this method of replacement. The distinctive feature, as also the special merit, of Dr. Register's appliance consists in the provision made for the ready replacement of broken crowns. The process is thus described :—

"Taking a typical case (Fig. 367), a rim or saddle of gold, platinum, or iridinized platinum is struck to fit the spaces between the teeth A and B. To this are attached bars X (Fig. 369), to enter the fillings at Z, Z (Fig. 368). Posts or pivots (D, Fig.

369) are soldered upon this saddle where the artificial teeth are to be placed, their free ends being threaded to carry the nut E.

Fig. 367.

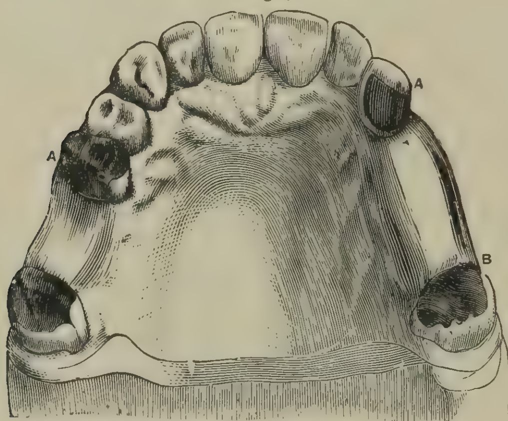


Fig. 368.

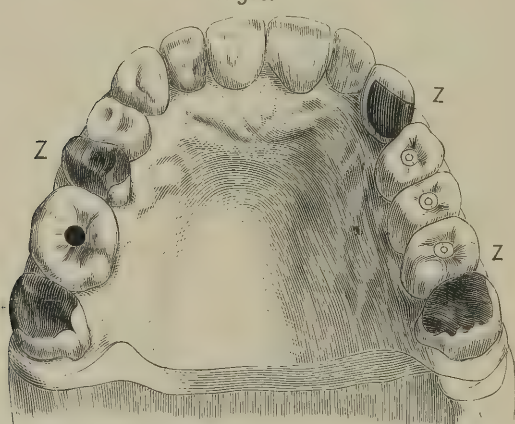
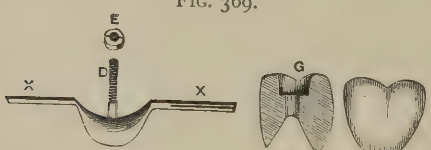


Fig. 369.



Hollow crowns, countersunk for the nut at G, and having the necks ground to reach over the saddle and press upon the gum,

are fitted over each post. Amalgam is used to fill in the space between the post and the tooth-wall, as in a Bonwill setting, and the crowns are drawn to place and held with the nut. The saddle is fixed in its place in the mouth, before the crowns are finally attached, by filling into the cavities Z the bars X, X."

Dr. Williams' Method.—Dr. J. L. Williams, of New Haven, Conn., has given to the profession a number of important communications relating to bridge-work, to which space is given to such portions only as relate more especially to practical details. The initial portion of the following, reproduced from the *Dental Cosmos*, treats also of single crown replacement, and is embodied in this connection as having immediate and necessary relation to subsequent descriptions.

The following are Dr. Williams' descriptions of his methods of crown and bridge replacement.

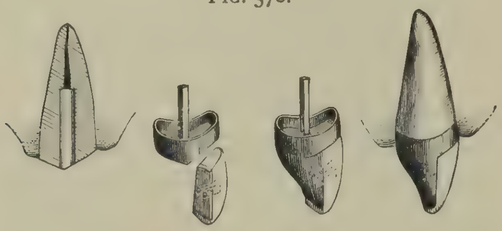
"As the single crown is the beginning and end of all bridge-work, a description of that particular form which is of the greatest practical value in this work will first be necessary. This is known as the Richmond Crown, although not the crown which Dr. Richmond claims as his invention. It consists essentially of three parts: a square pin of platinum and iridium which enters the enlarged pulp-canal, a cap of gold, and the porcelain face, which is the ordinary plate tooth.

"This crown is made in the following manner: After the end of the root is made perfectly smooth with corundum wheels and properly-shaped scalers, a gold ferrule or band is fitted around it. If it is desirable that this band should be entirely concealed, the labial surface of the root should be beveled a little above the margin of the gum, and after the band has been soldered it may be placed in position, and the line of contour of the margin of the gum marked upon the front of the band. The proper bevel can then be cut and the edges squared upon a corundum wheel, leaving the lingual portion of the band a little longer than the front. Pure gold, rolled to No. 34 of the standard gauge (American), is used for soldering upon the beveled surfaces, thus making a closed cap for the end of the root. A suitable tooth is now selected and backed with pure platinum or pure gold. The cervical end of the tooth is then ground to the

proper position on the front bevel of the cap, all of the fitting being done while the cap is in position on the root.

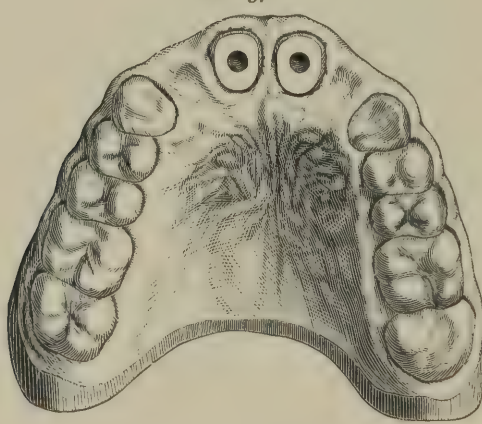
"After the fitting is completed, the cap is removed, and the tooth attached by strong resin wax and again placed in position while the wax is warm. Any slight change in position which

FIG. 370.



is necessary can then be easily made. The tooth and cap are now removed together, invested, and united at the back by solder. It is well to use a solder for the cap with a higher melting-point than that used for the backing, as it obviates the

FIG. 371.



danger of unsoldering the band when the backing is flowed on. After finishing and polishing the work, the end of the root is made perfectly dry, a sufficient quantity of oxyphosphate cement, mixed somewhat thinner than for filling purposes, is placed in the enlarged pulp-canal and also in the cap. The crown is then

carried to the place with firm, steady pressure, and held a few minutes until the cement is sufficiently hard to prevent displacement. The surplus cement which has oozed out around the band should be carefully removed and the work is then completed. This is all illustrated in Fig. 370.

"The bridge-work is simply an extension of the crowns over spaces where the natural teeth have been lost.

"Fig. 371 was drawn from a model of a case in practice. In this the roots of the centrals are shown prepared for the fitting of the bands, the laterals having been extracted. Single crowns are made for these roots precisely as described. They are then temporarily placed in position. Laterals are selected, backed, ground, and fitted to position. The laterals are then attached by means of strong wax to the centrals, carefully adjusted in the position which we wish them to occupy, and the whole removed in an impression of investing material. An additional quantity of investment is mixed and poured over the exposed ends of the caps, and the whole allowed to harden, after which the investing material is cut away from the backs of the teeth and crowns, after which they are all united by soldering.

FIG. 372.

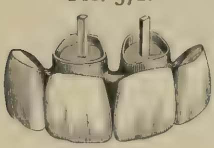


FIG. 373.

"Fig. 372 shows the work completed, and Fig. 373 is from a model of the mouth as restored with the crowns.

"In cases where the space is occasioned by the loss of more than one tooth a somewhat different method of procedure is necessary.

"Fig. 374 shows a model of a mouth in which the superior laterals and centrals had been extracted. The canines were badly decayed, with exposure of the pulp. The first step is the removal of the pulps from the canine roots. The crowns are

then fitted as already described and placed in position. An impression is taken in plaster, the crowns remaining embedded on its removal. The impression is varnished and oiled, and a model of investing material poured. After this has hardened, the impression is carefully cut away, and we have a model of the mouth with the crowns in position. A 'bite' is taken and the articulation secured in the usual manner. The remaining crowns, having been backed, are fitted, and the face of the work embedded in investing material.

"The whole piece is now united at the back by soldering, and when finished presents the appearance shown at Fig. 375.

FIG. 374.

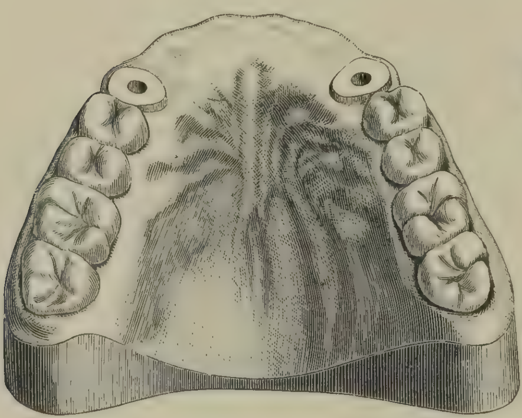
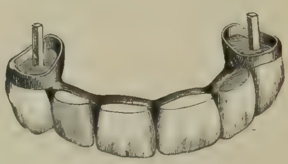


FIG. 375.

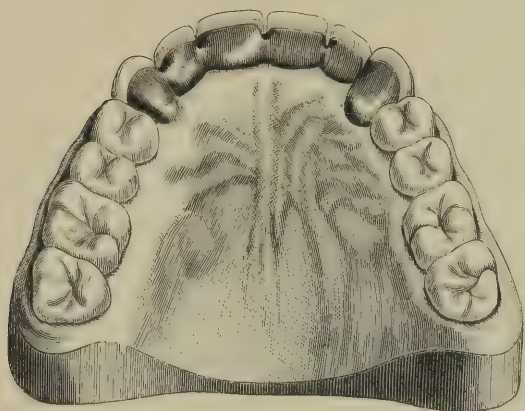


"Fig. 376 shows a model of the mouth after the bridge has been cemented in place.

"Fig. 377 is an illustration of a piece of this work for which there is a very frequent demand. It is for supplying the loss of the first molar and bicuspids. If the canine is intact, the anterior end of the bridge may be attached by a strong band of clasp metal passing around the canine, partly beneath the margin of the gum, so as to present the least possible exposure. If, as is frequently the case, there is extensive decay, it will be best to excise the remaining portion of the tooth and replace an artificial crown as shown in the illustration. A gold cap is then made for the second molar. If this tooth is decayed it will only

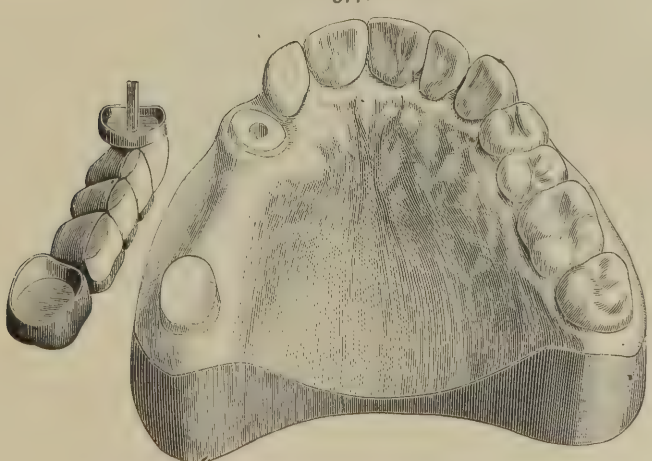
be necessary to remove the decay, and the cement which is used for setting the bridge will make the most perfect filling

FIG. 376.



material beneath the gold cap. The intervening molar and bicuspid crowns are made in the following manner: the porce-

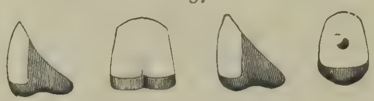
FIG. 377.



lain faces are backed with gold or platinum and the tips ground squarely off. Zinc pattern dies, an assortment of which should

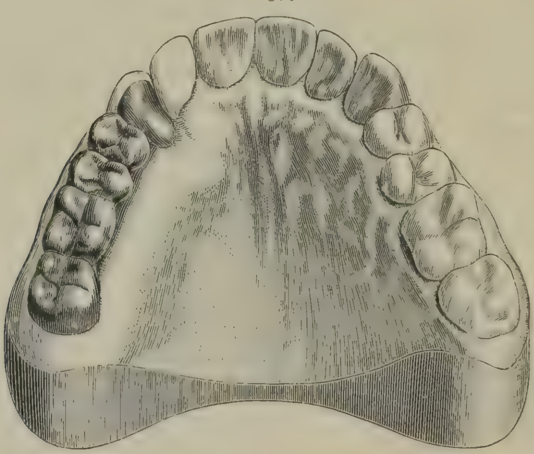
be made from the grinding surfaces of molars and bicuspids, are used for swaging from pure gold a tip or cap for the protection of the porcelain face; for without this protection the porcelain would be almost certain to be broken. The concave surface of these tips is filled by melting coin-gold into them. This surface

FIG. 378.



is then ground smooth and fitted to the squared surface of the porcelain face and waxed in position. Triangular pieces of platinum are then cut of the proper size to fit the sides of the tooth, waxed in position, and the whole invested, leaving the back open, which is filled with coin-gold.

FIG. 379.



"These teeth are then fitted into position in the bridge, as previously described.

"Fig. 379 shows the completed work in the mouth.

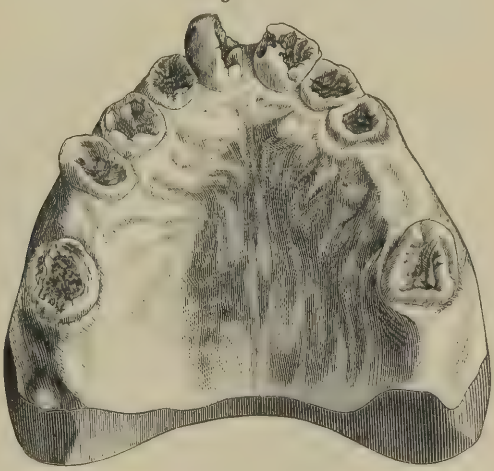
"Where only one molar or bicuspid is lost, sufficient support may be gained by the cap, which is made to pass over the adjoining molar. If the first molar and second bicuspid are lost,

the anterior end of the bridge may receive sufficient support from a strong spur (Fig. 380), which may rest in the groove or sulcus between the cusps of the first bicuspid; or this groove may be deepened into a cavity, into which the spur projects and around which a filling is placed.

"The most extensive pieces of this work which have been attempted are cases of twelve and fourteen teeth upon three and four roots. Several of these have been worn for a year or more, and none of which I have any knowledge shows any signs of failure.

FIG. 380.

FIG. 381.

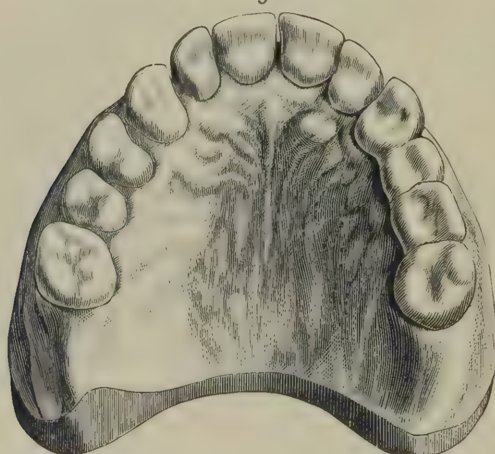


"Perhaps I cannot better close this paper than with the description of the restoration of a mouth where any attempt to remedy the ruin save by extraction would have been considered madness; and yet the lady for whom this work was accomplished is, to-day, so far as appearance, utility, and comfort are concerned, enjoying as perfect a denture as any person who has the same number of natural teeth intact.

"Fig. 381 was drawn from a model of the mouth as presented. Only one tooth remained the pulp of which was not exposed—the left second superior molar. In the first bicuspid, canine, and central of the left side the pulps were exposed and in a partially putrescent condition. Abscesses had formed about the roots of

the second left bicuspid, right central, canine, and second bicuspid. The pulp was slightly exposed and inflamed in the right first superior molar. The second bicuspid on the right side and both bicuspids on the left were extracted at once as worthless. The exposed pulp in the right molar was treated and capped. The partially living pulps were removed from the teeth above mentioned, the fistulous openings were healed, and all of the roots thoroughly cleansed, and plugged with orange-wood saturated with carbolic acid and glycerin. The greatest difficulty was encountered in the treatment of the right canine root, which had two large openings through the side of it, and through

FIG. 382.



which projected into the enlarged pulp-canal a tumefied growth of the pericementum. For several weeks the tissues around this root were highly inflamed, and the face was several times badly swollen. The difficulty was finally overcome by covering these openings with No. 30 gold foil and filling the root with amalgam. Crowns were then fitted over all of the roots. A bridge was then extended from the left canine to the first molar to restore the lost bicuspids. The missing bicuspid on the right side was restored by attaching the crown to the cap which was placed over the molar containing the exposed pulp.

"Fig. 382 was drawn from a model of the mouth as restored.

"In conclusion, I desire only to repeat what I have already substantially said, that this work opens up a new field for the usefulness of our profession, which will bring joy to the heart of every conscientious dentist. Its possibilities are almost unlimited."

A continuation of the subject of bridge-work, with illustrative cases, by Dr. Williams, is contained in a later number of the *Dental Cosmos*. These descriptions are introduced here, accompanied by some preliminary comments on the antecedent treatment of the organs of support, a precautionary measure which all recognize as of vital importance, especially in connection with artificial substitutes immovably fixed in the mouth. The following is the contribution referred to, a portion of the preliminary matter being omitted :—

"Knowing that the value of these artificial substitutes for the natural teeth is entirely dependent upon the conservation of the teeth or roots upon which they are mounted, and believing that the methods of treating these roots which have been worked out in connection with the system known as crown- and bridge-work are superior to those practised by the majority of the profession, I am disposed to devote considerable space to this part of my subject. Before describing the several modifications of bridge-work illustrated in this article, I desire to call attention to a few of the cases which I have treated, and which are more or less radical departures from those ordinarily met with.

"Case I.—This case was reported in the *Independent Practitioner*, and from it I quote as follows: 'Mrs. S. had been wearing a pivot-tooth on the root of the upper right central for several years, and as it required frequent re-setting she desired to have it replaced by a more permanent operation. On removing the crown the root was found in a bad condition. Decay had penetrated the side of the root, leaving quite a large opening into the pericementum. An enlarged foraminal opening led to a cavity at the end of the root, from which an offensive pus was discharged. But the root was very firm, and promised to give a secure foundation for a crown if it could be brought into a healthy condition. A little cowardice prompted me to attempt the treatment through the root, but after a week's effort my

ambition in that direction was satisfied, and I resorted to a method which has proved eminently successful in several cases of this character. The end of a soft, smooth broach was bent so as to form a little hook. This was passed up the enlarged pulp-canal until the hook slipped over the end of the root. The broach was then seized with pliers at a point exactly opposite the external end of the root and drawn out and the length carefully measured.

"'A point of orange-wood was carefully shaped to fit the pulp-canal, a notch cut on one side, showing the exact length of the root inside, and after dipping in a solution composed of equal parts of carbolic acid, chloral hydrate, and gum camphor, it was driven into the canal until the notch appeared precisely opposite the end of the root. I know of no other method by which an enlarged pulp-canal can be so perfectly filled, with a certainty that the filling material has gone exactly to the end of the root, and no further.

"'The wood point was twisted off at a point about half the length of the root, where it had been weakened by passing a knife around it, cutting partly through. Heavy gold foil was placed over the opening in the side of the root, and the large funnel-shaped opening filled with amalgam. An external opening was made opposite the end of the root, and the diseased bone and end of the root cut away with rose-burs. A cotton tent was kept in for two days. On the third day a crown was placed on the root, and in ten days the external opening healed and all irritation had passed away.'

"Case II.—Mr. W. had a central incisor broken near the margin of the gum by a base-ball. The pulp was removed and the canal filled with gutta-percha. Inflammation followed and an abscess threatened, which was prevented by removing the filling. When he came to me the canal had been open for more than a year, and from it there had been more or less constant discharge. On examination I found it filled with black and very offensive matter, which had stained the dentine to a considerable depth. After syringing with warm water, I enlarged the canal materially and passed directly through the end of the root with a rose-bur. I enlarged the cavity which I found at the end of

the root until I had produced quite a copious flow of blood through the canal. After the bleeding had ceased, a broach wound with cotton was dipped in chlorid of zinc, twenty per cent. solution, and passed up through the root. After this treatment the canal was simply dressed with Listerin for ten days, the dressing being changed every day. At the end of that time, there being no discharge (in fact, I could not discover at any time after the operation that there was any discharge of pus), the root was filled precisely as described in the preceding case, and a Richmond crown mounted upon it.

"I believe the most rational treatment for the persistent pathological condition which remains around the roots of teeth which have been the seat of alveolar abscess may be summarized in a single short sentence. If the source of the primary irritation remains, remove it; cleanse the root thoroughly and fill it; then *reduce the territory of perverted physiological action to the condition of a simple wound, and treat it as such.* If the case is one of long standing, I enlarge the external opening and enter the cavity at the end of the root with a large rose-bur, cutting out the walls of the cavity and trimming the end of the root. Syringe out with warm water; inject a ten per cent. solution of chlorid of zinc, and insert a cotton tent for a few days. Dress the wound—for this is what you now have—daily, syringing with peroxid of hydrogen, followed by Listerin. I believe this simple treatment will cure the most persistent cases of abscess, or, more properly speaking, alveolar ulcers, in from ten days to two weeks. The medication of these ulcerated tracts for many weeks, and sometimes months, is neither humane nor scientific treatment.

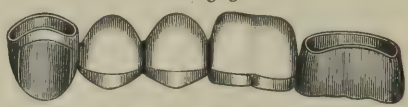
"While I have thus written encouragingly of the practice of retaining pulpless teeth in the jaws, I would always *dis*courage the removal of healthy pulps, except when absolutely necessary. But the operator should not hesitate to do this when convinced that the patient will be greatly benefited by the insertion of a piece of work which necessitates the removal of a healthy pulp. However, the constant modifications and improvements in the methods of constructing the work are making the removal of pulps more and more unnecessary.

"We will now proceed to consider the principal object of this

paper, which is the illustration and description of some of these improvements.

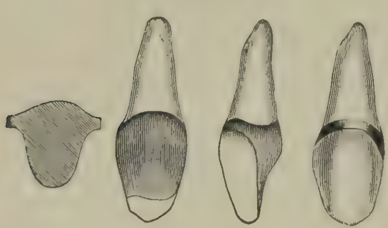
"Fig. 383 shows a piece of work made for a case of quite frequent occurrence. It represents the restoration of the inferior

FIG. 383.



bicuspids and first molar of the right side. A gold crown is made for the second molar, and then the three intervening teeth or 'dummies' are made as described in my former paper. For the support of the anterior end of the bridge the method hitherto practised has been to excise the crown of the cuspid and fit a porcelain crown with gold backing to the root, and to this the anterior end of the bridge is soldered.

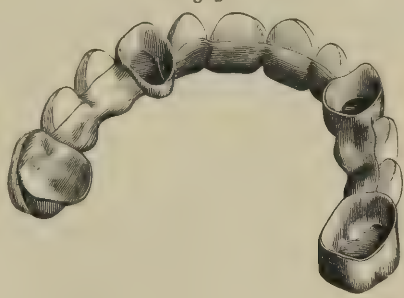
FIG. 384.



"Fig. 384 illustrates a device which obviates the necessity for removing the cuspid crown. A gold band is fitted around the cuspid. At the front, shown at *a*, this band is allowed to pass a little beneath the margin of the gum so as to make the smallest possible exhibition of gold. On the lingual aspect of the tooth this band is allowed to be nearly the length of the crown. It will be seen that when this band is fitted as perfectly as possible there must necessarily be quite a vacancy between the upper part of the lingual surface of the tooth and the band. It is important that this portion of the band fit the tooth perfectly, and an accurate adaptation is obtained as follows: A piece of pure gold, rolled to No. 35 American gauge, is fitted over that portion of the lingual surface of the tooth which it is desired to cover. *d*, in Fig. 384, shows the shape that this little pure-gold plate usually assumes. It can easily be fitted perfectly by the use of

a burnisher, and then, with the band in position, a drop of melted resin wax is flowed into the space between the pure gold and the band. It is now removed from the tooth, invested, and, after melting out the wax, solder is flowed into the vacancy, filling completely the space occupied by the wax. The top of the lingual portion will now be thicker than is necessary, but can be easily ground or filed down to the proper thickness. We now have a band which fits all portions of the tooth perfectly. The anterior end of the bridge is soldered to this band, and after the work is properly finished it is cemented in place in the usual manner. *b* and *c*, show side and lingual views of this band after the fitting is completed.

FIG. 385.



"Figs. 385, 386, and 387 illustrate a method of inserting extensive pieces of bridge-work in cases where there are no natural teeth or roots for supporting one end of the bridge. The work from which these

FIG. 386.

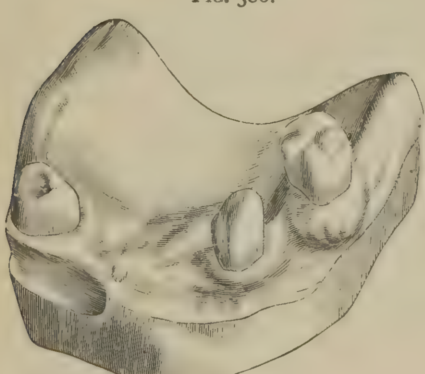
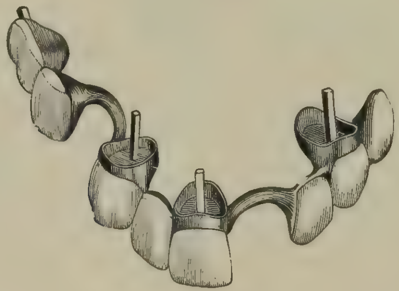


FIG. 387.

drawings were made was constructed by Dr. H. A. Parr, of New York. By this method bridges may be inserted in cases where

all of the teeth on one side of the mouth have been lost, or where all of the teeth anterior to the molars on both sides are wanting. Crowns are first fitted to the teeth which remain. These crowns being in position, an impression is taken. From this a cast is obtained with the crowns in their proper positions. A second impression is also taken of that portion of the mouth where there is no natural support for the bridge. From this impression metallic dies and counter-dies are obtained, from which is 'struck' a small gold plate about three-fourths of an inch in length and width, the size of the plate varying according to position and other conditions. After this little plate or 'saddle' has been perfectly fitted, it is waxed in the proper position on the model with the crowns. The intervening teeth are now placed

FIG. 388.



in position, and the work invested and soldered. I have had no practical experience with this method, but Dr. Parr informs me that he has inserted several cases which are being worn with perfect satisfaction. To provide for the possibility of shrinkage or absorption at the point where the plate or saddle rests, I would suggest that it be not soldered to the bridge, but attached by means of an adjustable screw.*

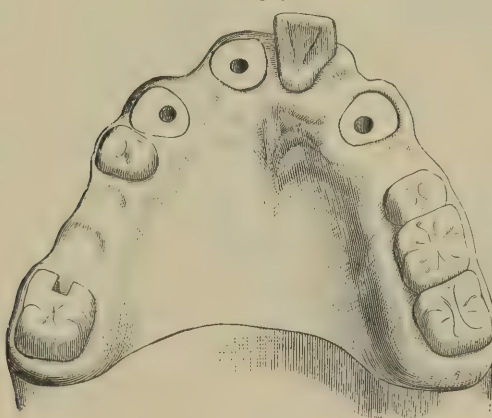
"Fig. 388 illustrates another device for obviating the necessity for removing the crowns of natural teeth in preparing the mouth for bridge-work. Crowns are fitted in the mouth to the points of attachment in the usual manner. An impression is taken,

* Too extensive use of this method of bridging, with plate or "saddle," should not be made, on account of the inability of the patient to keep it clean.—ED.

bringing the crowns away in their proper positions. From this the cast or model is obtained. Heavy bands of half-round gold or platinum bars are now fitted around the necks of the natural teeth on their lingual surfaces. These bands being waxed in position, serve to connect the different parts of the bridge, uniting them in one piece without the loss of any of the natural crowns. I have found this a highly satisfactory method of inserting extensive pieces of the work. Fig. 389 shows the mouth as presented for which the piece shown was constructed. Fig. 390 shows the piece in position.

"Fig. 391 illustrates a case which is a type of a class of frequent

FIG. 389.



occurrence. Alternate molars and bicuspids in the upper and lower jaws are lost, until the occlusion is somewhat changed, and the force of mastication is gradually brought upon the front teeth. Rapid wearing of these teeth results. The cases are among the most difficult that the operator is called upon to treat by the ordinary methods. In the case herewith illustrated, the lower bicuspids with a molar on one side were in good condition, but the loss of the upper bicuspids and molars made them useless. As usually happens, the upper incisors had suffered most. The lower incisors were restored by capping them with cohesive foil. The bridge shown in Fig. 392 was constructed for the

right side of the upper jaw, while the teeth on the left side were restored by contour work, as shown in Fig. 393.

"The superiority of the condition of this patient's mouth, which resulted from this work, over anything which could have been accomplished by plate work, is almost inconceivable to one not familiar with these methods.

"The only annoyance which bridge-work is likely to cause patient or operator is the occasional breaking of a porcelain, an accident of not frequent occurrence. While the replacing of a broken porcelain has never been a matter of extreme difficulty, yet I have always regarded the methods hitherto employed as more or less imperfect and uncertain in their results. This led me to devise a method of replacing broken porcelains which leaves the work fully as strong as before; a method which makes the operation a very simple one, requiring less than an hour for its performance; and after the porcelain has been replaced an expert would not discover any traces of an accident. After removing all traces of the broken porcelain, the projecting pins are cut off, and two holes drilled through the backing in the exact position occupied by the pins. The narrow space of metal now intervening between these two holes is cut out with a fissure-bur. This leaves a groove which should not be wider than the diameter of the pins. The length of this groove should now be increased on the lingual surface, but not on the front. The object of this is to give a dove-tail shape to the groove, which is easily effected by the use of the same fissure-bur above referred to. The lingual appearance of this groove when properly shaped is shown in Fig. 394. The proper tooth is selected, the pins passed through this hole and bent outward into the dove-tail groove. It will be found almost impossible to bend these pins into their proper positions by any ordinary means, so as to hold the tooth

FIG. 390.

quite rigid and immovable. An instrument herewith illustrated (Fig. 395) accomplishes this feature of the work in a very simple and effective manner. Its use is almost too nearly evident to require description. Both the rubber pad which rests upon the

FIG. 391.

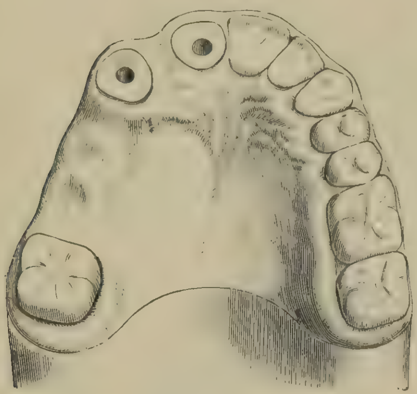


FIG. 392.

porcelain front and the wedge-shaped point which passes between the pins are made to rotate in their sockets, so that any desired position can be obtained. A firm closure of the instrument when in position forces the pins outward into the dove-tail groove, and the tooth is immovably fixed in place. It now remains but

FIG. 393.

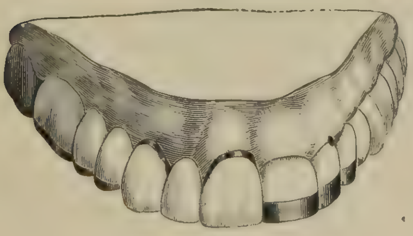
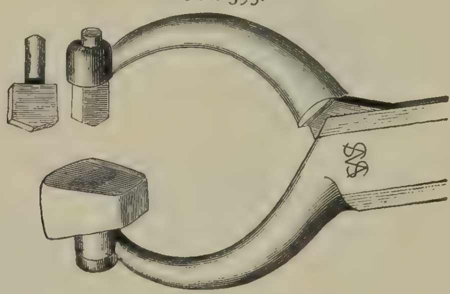


FIG. 394.

to fill the space between the pins with any form of cohesive gold (I use crystal gold), and with corundum, Arkansas, and rubber points in the engine the surface is finished and polished. The wedge-shaped filling of crystal gold acts as a keystone between the pins, and makes a most perfect method of repair.

"The practice of extracting badly-decayed and broken-down teeth, particularly when they become a source of constant annoyance, and replacing them with artificial substitutes mounted upon rubber, celluloid, or metallic plates, has become so firmly established in the public and professional mind as the proper and unavoidable thing, that the folly of such practice can only be demonstrated by persistent and long-continued endeavor. The statement, therefore, that it is no less a criminal practice, *in principle* if not in degree, to extract a tooth because it is in an ulcerated or broken-down condition, than would be that of amputating a finger because of the appearance of a felon, or removing an eye to get rid of a cataract, will seem a radical one. But if my experience has taught me anything, it certainly is no exag-

Fig. 395.



geration of fact. Diseases of the teeth and the surrounding tissues are certainly as amenable to treatment as are ulcers or morbid growths in other parts of the body. The only conditions necessary to the successful accomplishment of this are requisite knowledge and skill in the operator and a desire on the part of the patient to have a healthy mouth.

"A properly made artificial crown mounted upon a root, the investing membrane of which is in a healthy condition, is quite as useful, and, all points considered, perhaps quite as desirable, as a pulpless tooth with its natural crown intact. Such is my confidence in the intrinsic merit of bridge-work that I think it requires no very great degree of foresight to predict that the day is not far distant when a large per cent. of the now prevalent partial-plate work will be a thing of the past."

Dr. Knapp's Method.—After constructing the crowns as directed on page 241, suitable plain plate-teeth should be backed with pure gold and built up to the desired shape with wax, Fig. 396, which should be incased in pure gold as before described, Figs. 397, 398, 399. After investing and subsequent removal of the wax, the resulting receptacle can readily be filled with twenty-carat solder, Fig. 400.

In the preparation and in the drilling of the roots, great care should be exercised to have the caps and the pins as nearly parallel as possible. Here, as well as elsewhere, sound judgment is essential to the accomplishment of the best results. For the attainment of accuracy, it is essential that an impression should be taken, preferably in plaster, of the caps in their proper positions upon their several roots. An impression should likewise

FIG. 396.

FIG. 397.

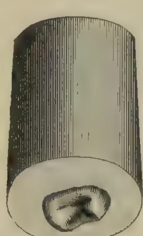


FIG. 399.

FIG. 400.

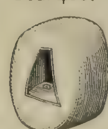


FIG. 401.

FIG. 402.

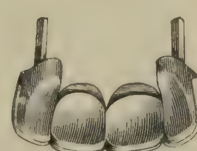


FIG. 398.

be taken of the occluding teeth. The models obtained from these impressions should then be placed in an articulator, as for plate work, and the articulating surfaces of the porcelain crowns should be carved in wax to a nicety. By the methods just mentioned these occluding surfaces are reproduced in gold. The requisite exercise of the dental organs and immunity from breakage of porcelain faces are in this way secured. The porcelains should not press upon the gums except in the anterior portion of the mouth, where the formation of the alveolar process permits and the perfection of speech demands it. The gold from the grinding surfaces should form a gradual slope until it reaches the porcelain, and should be entirely free from pits and other irregularities. When they occur, it becomes necessary to remedy these as well as other defects. This is to be done by the re-firing

of either a single crown or an entire piece of bridge-work. At times gold, where needed, may be added by the use of the electric mallet, and a beautiful finish obtained with it. Under all circumstances, both porcelain and gold should present a perfect continuity of surface. With diligent attention given to the important details of construction which are here pointed out, the great bugbear of uncleanliness, suggested as an objection to this method of substitution, is entirely removed. Of course, food and salivary deposits will accumulate around artificial crowns as well as about natural teeth, and the personal cleanliness of the wearer is the greatest and indeed sole safeguard against such injurious accretions with any denture. A philosophy that would condemn the insertion of bridge-work, artistically constructed on scientific principles, on the score of uncleanliness, would as consistently advise the extraction of the natural organs for the reason that their possessor was a sloven. "Cleanliness is next to godliness," says Wesley, and he who expects to wear a "crown," here or hereafter, must heed this maxim.

Fig. 401 shows an upper central and lateral incisor mounted upon a central root with spud attachment. Fig. 402 represents the four upper front teeth held in position by the two lateral roots. Fig. 403 the six upper front teeth mounted upon the two cuspid roots. Fig. 404 represents a full upper denture with the two cuspid roots and two molars as anchorages.

For the attachment of crown and bridge-work the best attainable oxyphosphate cement should be used. With the pins notched, and the roots perfectly free from moisture, sufficient oxyphosphate should be placed around each pin and inside of the collar to completely fill all the space between the pin and the canal, the collar and the root. Firm, well-directed pressure should then be exerted to carry the piece to its proper position, where it should be held for a few minutes to permit of the hardening of the cement, all excess of which oozing through at the edge of the collar should be carefully removed. Before being dismissed the patient should be instructed to be a little cautious in regard to subjecting the crown or bridge to any force for a short time.

Dr. Low's Method.—The following illustrated account de-

scriptive of Dr. J. E. Low's methods of procedure in the cases under consideration was especially prepared by him for this work. His definition of "bridge-work" has special application to his distinctive method of construction. It is as follows:—

"Bridge-work consists of supplying vacancies between teeth or roots with artificial teeth, attached to the adjoining natural teeth or roots by means of bands or crowns, and held in such a position that there is no contact with or pressure on the gums beneath, and thus no opportunity for secretions or other foreign matter to be held there, and thereby become offensive.

"There is really but one kind of bridge-work, and but one way to make bridge-work to insure success. There are many ways

FIG. 403.

FIG. 404.

of making teeth without plate, but this is not bridge-work. I will here try to explain in detail my manner of making and adjusting bridge-work.

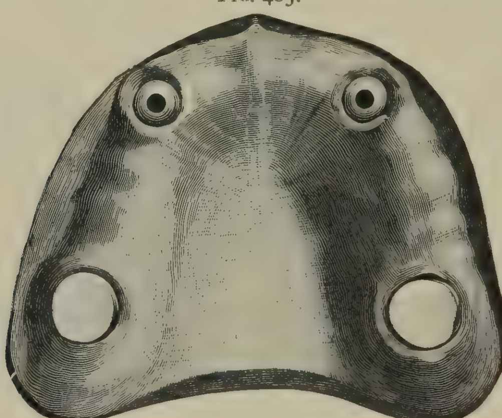
"For the first illustration, as seen in Fig. 405, we have a case where all the teeth have been extracted except the two cuspids and two second molar roots.

"We first proceed to prepare the roots by crowning. I use gold crowns on the molar teeth, and what is known as the Low crown on the cuspids. The preparation of the two cuspids consists in making the crown ready for adjustment, the process of which is described in detail in another part of this work (page 258). I always measure the tooth to be crowned with gold

with a strip of block tin, No. 35 thick Stub gauge or thereabouts. Place the tin around the tooth and with pliers carefully measure the full size of the same.

"Should you be measuring a tooth, or part of a tooth, on which there are projections, take the engine, and with a stone grind off the same, making a smooth surface, so there will be nothing to interfere with the fitting of the bands properly. After cutting the tin measures by the marks made by the pliers, you have the measures ready to make the gold bands by. Cut the bands and bevel the edges and solder together, and you are ready to fit. After fitting all the bands and finishing the crowns in the usual

FIG. 405.



way, I place each in position in the mouth, having previously regulated the articulation of each crown as desired, in the process of making. We now take a deep articulation in wax, and impression in plaster-of-Paris; remove before it gets too hard, and place all the crowns in their positions in the impression; varnish, oil, and pour in the usual way; separate the cast from the impression and place in the articulator. Then pour with plaster. After the plaster has hardened, remove the wax, and we have the articulation proper, and are ready to select and grind our teeth, having previously selected our shade. My experience has long ago taught me that no porcelain tooth can stand the pressure for bridge-work, the strain on them being twice as great as with teeth

on plates which rest on the gums, that give to pressure. In order to prevent breakage of teeth and give strength, I have for many years been making a tooth with gold cusps. I will here describe my manner of doing so.

"For the first step, I use No. 28 gauge platinum for a covering of the inside of the tooth, or just where you wish gold to flow. Then I bend the pins down to hold the platinum in position, and with a file remove all overlapping platinum to prevent breaking of our tooth in heating. The tooth is made flat on the crown surface with the express intention of restoring with a gold crown. This crown need not be very thick, but should perfectly resemble the cusps on the natural tooth, for the purpose of mastication. As these cusps are not on the market, and every dentist making bridge-work cannot make it in a way to stand without putting gold cusps on the grinding surface of the bicuspids and molars, I will here describe, for the benefit of those who do not know how to make them, how they can be made with very little trouble. Pick out a natural tooth with cusps the exact shape you wish to have your gold cusps resemble; mix up some fire clay in a thick paste; then press your tooth into it a little deeper than you wish the cusps. Having made the proper impression, remove the tooth, and set the impression over the gas stove to dry. After it is dried and reasonably hot, lay your pieces of gold in the impression and with a blowpipe melt them. When melted, press with a piece of steel on the gold till cool. This mold will do to make many from. If you have not the fire clay, and can get charcoal that is burned from fine-grained wood and is soft, you can simply press your tooth into the charcoal and melt in the same way, or you can carve your teeth as you desire in a block of carbon. Of course, the little steel dies are handier, as we can swedge up our gold cusps in them, either solid or thin.

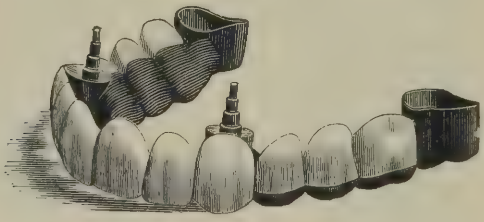
"Having described our manner of making the cusps, we will now return to the manner of finishing our tooth. We left off by saying we covered the inside and bent down the pins and filed off the overlapping platinum. We now place our cusp on the top of the tooth, and place in the position desired, holding it there with wax, and with a spatula trim the wax the exact shape we wish our tooth to be, V-shaped, tapering from the crown down.

We now encase in plaster and sand, which gives us a box. When hard, remove the wax and place over the stove, and when sufficiently dry, fill in with coin-gold, using the blowpipe to melt it in a solid mass, and our tooth is ready to file up and place in position on the articulator. Fig. 406 shows the tooth in this condition.

"After our teeth are arranged, we hold the same in position with wax, remove from the articulator, encase with plaster and sand or asbestos in the usual way. That we may have a strong case, I always use platinum wire between each tooth, and then proceed to heat and solder. Be sure that all the gold cusps are so arranged that you can get it all soldered together, as this gives us great strength. My formula for solder, which I have used for many years, and which will be found very easy-flowing, and almost the exact color of the gold you are using, is as follows:

FIG. 406.

FIG. 407.



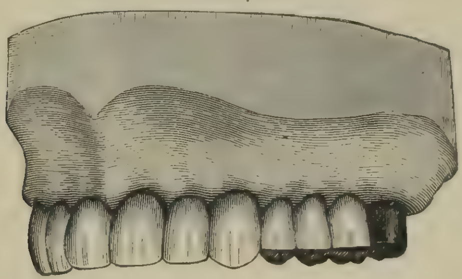
Always figure from the carat of gold you are working. Take 1 dwt. coin-gold, 2 grains of copper, and 4 of silver. We now have our case soldered; after filling as desired, commence to finish with felt wheels and pumice stone, after which use rouge buff wheels. It is now ready for adjustment in the mouth. In Fig. 407 we see the case ready for adjustment.

"Have the assistant dry all the teeth or roots to be operated upon while you are mixing the cement. Be sure and use a kind which will not harden very rapidly, or your cement will set before you get your teeth adjusted. Use sufficient cement to fill all the gold crowns perfectly when the case is driven to place. Moisten the step-plugs and cap with cement, touching every portion, and with an instrument place a little cement in the bottom

of the cavity. We now adjust our case, using the little roter for the Low crowns and a piece of ivory for driving on the gold crowns. Fig. 408 represents the case when in position.

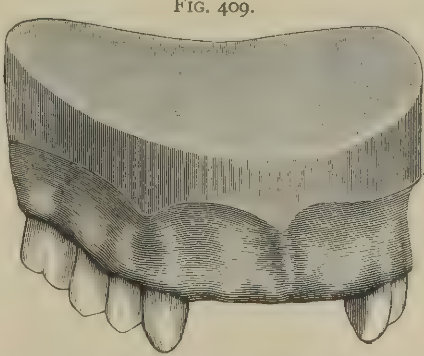
" It will be seen by looking at the previous cut (Fig. 407), that the teeth, after having been soldered, are all spaced fully one-

FIG. 408.



third of the distance from the place ot contact with the gums and the grinding surface of the teeth, so that secretions could not possibly lodge there. I have given a description of my manner of making a full upper case of bridge-work where there are roots to be crowned to support the bridge. I will now describe my manner of operating upon a case where the four centrals are missing, as seen in Fig. 409; to supply these four teeth where the cuspids are intact, I use a gold band.

FIG. 409.



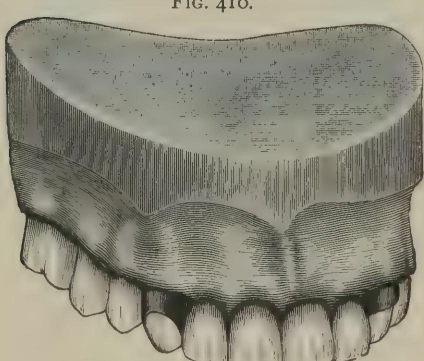
" I first measure the tooth with strips of tin, and make the gold bands, as before described; cut out the outside lower portion of the band before beginning to fit. In fitting, as the band is being driven down, cut away any of the band that touches the gum before all touches; never drive the band any distance under the gum, as inflammation would probably follow.

" I mention this, as I have seen many attempts to get rid ot

the band by driving up under the gums and cutting them out on the front, until they were too narrow for strength. It is hard work to make something out of nothing. The bands should be heavy and strong, and the patient made to understand that if he expects to get rid of the annoyance of the plate, he must sacrifice his dislike to showing gold. After driving the bands up to the margin of the gums, as the cuspid teeth are very tapering, the bands will have to be taken in at the bottom. To do this slit the band about a third of its length up, then place it on the tooth again, lap it over enough to bring it to a close fit, and then take it off and solder.

"Continue taking it in wherever it does not perfectly fit the tooth, and after a good fit is obtained proceed as before described, by taking an articulation and impression. In adjusting, first try the case on to see that it fits, and that the articulation is all right. Next have the assistant dry the teeth upon which the bands are going, and then mix your cement. This should be mixed to about the consistency of thick cream. It must be neither too thick nor too thin, or the adhesion will not be strong enough to hold. Cover your teeth with cement and then the inside of the bands. Place these on the teeth and carefully mallet to position. For this purpose I use a steel instrument, with a crease or groove in the end. The teeth must be kept dry, after the case is in position, until the cement is well set. After this is done, bevel the edges of the bands and burnish close to the teeth, and if burnished properly they will be made to resemble gold fillings. Fig. 410 represents the case completed.

FIG. 410.



"I am aware that, in a case like this, porcelain crowns instead of gold bands could be used, and I should consider it much preferable to do so where we have roots or unsound teeth to operate

upon, but do not advise the destroying of nerves, where the teeth are intact, to supply such a case with crowns, as the bands will answer every purpose for many years.

"If they should give out in after years, the roots can then be crowned. I have many of these cases that have been in use eight and nine years, some of which have never loosened, and some I have reset nearly every year. I always impress upon the patient the necessity of having them reset immediately should they become loose, and advise them to have their cases examined at least once a year. Should parties insist upon having crowns used to supply a case, like the one just described, on perfectly sound teeth, I should begin by using an aluminum disk, with corundum, cutting deep as possible, both on the labial and lingual sides. Then use the excising forceps. This can be done under the influence of an anesthetic, or otherwise. It is not by any means so painful an operation as one would think. If the nerve does not come out with the piece of tooth cut off, I take a piece of orange wood, which I have previously cut the proper shape to drive into the nerve canal and placed in creosote a few minutes before beginning to operate. Immediately after severing the tooth, drive this into the canal, then remove, and dip in creosote and drive in again. This will perfectly fill the nerve canal; all sensitiveness will disappear, and you can begin to operate at once. I do not recommend this treatment for sound teeth, but I have treated many exposed nerves in this way; also, many teeth broken by accident, and think this the most satisfactory way to dispose ot such cases. I have never had any unfavorable results follow after operating upon teeth in this way, and I can hardly say as much in favor of any other treatment. I speak of this manner of treating exposed nerves as one of the operations that sometimes becomes necessary in adjusting a bridge properly. I do not claim any originality in this mode of treatment. I know several dentists who use this method, all of whom report satisfactory results. We now have the roots prepared to receive the case as shown in Fig. 411.

"I have many of these cases in use that are giving entire satisfaction. The instrument selected for preparing these roots

should be one with small inside cutters and large bevelers, so as not to cut away any more tooth-substance than necessary.

"Fig. 412 shows the case ready for adjustment, and Fig. 413 represents the case after adjustment.

"In this article I have described my manner of making teeth

Fig. 411.

for bridge-work. I am now having made a tooth expressly for bridge-work which I hope to be able to place on the market soon. I have been using them, but have not perfected my

Fig. 412.

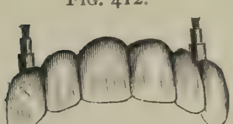
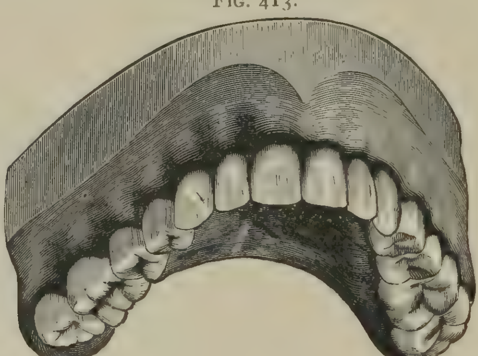


Fig. 413.



shells and molds sufficiently to enable me to get them out in large quantities.

"Fig. 414 shows us the sockets, which I propose to have ready made in various sizes, in bicuspids and molars.

"Figs. 415 and 416 represent the shells, which are to be placed in their positions after the case is completed and ready for adjustment.

"Fig. 417 represents the sockets as made for the four central and two cuspid teeth. The advantage of these teeth can readily be seen, not only for bridge-work, but for all-gold plates. A tooth, if broken, can readily be replaced without removing the bridge or cracking by soldering, and at small expense.

FIG. 414.


FIG. 415.


FIG. 416.

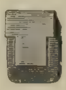

FIG. 417.


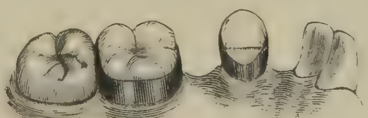
FIG. 418.


FIG. 419.


"Figs. 418 and 419 represent the teeth placed in position."

Dr. Melotte's Method.—Dr. G. W. Melotte, of Ithaca, N. Y., contributed to the *Dental Cosmos* an account of his method of bridging in a given case, the manipulative details of which are here reproduced :—

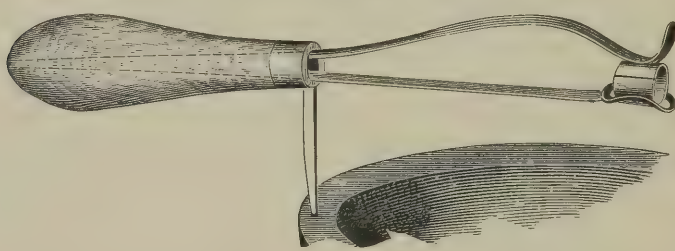
"Fig. 420 illustrates a case for the supply of a lateral and a bicuspid. In this instance the cuspid should be cut off, and the root collared and capped in combination with a pin entering the enlarged pulp-canal; but, as there may be grounds for ob-

FIG. 420.


jection to cutting off sound teeth, I obviate the necessity by cutting a shoulder on the lingual portion of the cuspid, and suitably shaping its sides to permit a close fitting of the collar just under the free margin of the gum. A narrow strip of pure pattern tin, bent tight around the tooth-neck, and cut through with a knife at the lap on the labial surface, will serve as a measure for the length of a strip of 22-carat gold plate, No. 29 thick, and as wide as the length of the distal side of the cuspid.

The ends of the gold are then squared, and with round-nosed pliers brought evenly together, to be held in flush contact by the soldering-clamp shown in Fig. 421. The soldered collar, with its joint side inward, is then adjusted on the tooth as accurately as possible, giving slight blows with a mallet until the collar touches the gum, when it should be marked to indicate the necessary trimming to conform it to the gum contour. After it has been thus trimmed, the edges beveled, the labial part swelled with contouring pliers, and the lingual part cut down to about one-tenth of an inch in width, the collar is again driven on, and will appear as seen in Fig. 420. A stump corundum wheel is then used to grind a shoulder on the lingual surface of the tooth, grinding also the edges of the collar flush with the shoulder. The collar is again removed, and a piece of thin

FIG. 421.



platinum plate, about No. 32, sufficient to cover the lingual surface of the tooth, is caught on the lingual edge of the collar by the least bit of solder, and all put in place on the cuspid (see Fig. 422). The platinum should now be burnished on to the shoulder, and over the tooth and collar to the extent shown by the lines in Fig. 422. After trimming to those lines, and carefully replacing and burnishing to the tooth, the collar and half cap are removed, filled with wet plaster and sand, and the platinum soldered to the gold. It is then placed on the tooth, burnished into all the inequalities of the tooth, very carefully removed, invested, and enough solder flowed over the platinum to cover and give it strength. Fig. 423 shows it complete on the cuspid.

" I have feared that a detailed statement would imply a long and tedious process, but I have often made such collars in less

than an hour, and in any case time must be made subservient to exactness of fit and adaptation to the end in view.

"In the preparation for fitting a collar on the first molar (Fig. 420) I should have wedged or otherwise separated it from the second molar, so that a piece of sheet brass might be put in place, as shown by Fig. 424, and an impression taken in plaster, which, if allowed to get hard, would bring away the metal. If not, it could be replaced in the plaster. Melted fusible metal, when near the cooling point, is then poured into the impression, and when cold will allow the safe removal of both the plaster and the metal strip. On this metal model a collar can be formed that will accurately fit the molar, as seen in Fig. 420. If the molar has no antagonist, a cap may at once be struck up on the model; but if there be an antagonist the cusps of the natural molar should be removed by grinding at points where the

FIG. 422.

FIG. 423.

FIG. 424.

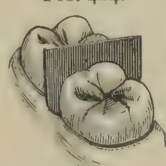


FIG. 425.

occluded tooth will admit of sufficient thickness of the gold cap. An exact copy of the ground cusps can then be made in less than five minutes by the use of moldine with its accessories, see page 151, and the process is as follows: Make the tooth perfectly dry. Put the collar on it. Nearly fill the cup with moldine, and coat it with soapstone powder. Press the compound on the tooth and collar firmly to about one-fourth the depth of the tooth. Carefully remove the cup; trim off any overhanging material, and place the rubber ring over the cup to about one-half the depth of the ring. Melt the fusible metal and pour it as cool as it will run from the iron ladle. As soon as the metal is hard, remove it with the ring, taking care not to impair the impression, which can be used again if the die is found imperfect or gets injured in use. Place the die and ring in cold water, to remain until quite cooled. While the die is wet and held

over a basin of water, pour into the ring fusible metal which has been stirred until it begins to granulate, and quickly immerse all in the water. The die and counter-die should separate readily by tapping them with a hammer, but if they stick, others can be quickly made from the same impression, by the same method, using more care. With this die and its counter-die, a piece of No. 29 or 30 gold plate is swaged to fit perfectly the cusps and collar, which, when removed, can be held to its place on the cap by the soldering-clamp, using spring pressure enough merely to hold them together for careful soldering with the pointed flame so as not to unsolder the collar. The seamless collars are excellent when care is used in selecting the proper size, as directed on the diagram.

"The caps being in place on the cuspid and molar, an impression is taken with plaster, the caps accurately set in the impression, and hard wax melted with a hot spatula around the edges of the caps. The impression is then thoroughly coated with sandarac varnish, after which it is dipped for a moment in water and filled with a wet mixture of one part marble-dust with two parts of plaster, using great care to perfectly fill the caps and molds of the teeth. Wait until this mixture has become quite hard, remove the cup, and with a suitable knife clip off the plaster without marring the cast; secure a good articulating impression, and transfer it to the cast to obtain an exact reproduction of the relative occlusions of all the teeth involved. With such an articulation in hand, and with the means already described for swaging gold or platinum plate to fit the cusps and articulating surfaces of either the natural or artificial teeth, it should be within the capacity of any competent dentist to complete a suitable bridge, although there are practical points that can only be imparted by clinical instruction and actual demonstration in the mouth. Such a bridge is shown in position in Fig. 425."

Dr. Parmly Brown's Method.—Dr. E. Parmly Brown describes a process of bridging which is characterized as "All-Porcelain." * This is true only in the sense that no metal is

* *Dental Cosmos*, vol. XXVIII.

visible, all parts of the metal framework being concealed within the body of the porcelain. The method is thus described:—

"Fig. 426 is a lateral view of a porcelain crown, with a platino-iridium pin baked in position. The pin has great strength at the neck of the tooth, where the strain is greatest, the porcelain of the tooth extending up on to it, to increase the strength.

"Fig. 427 is a front view of the same crown, showing by dotted lines the form which the metal occupies in the crown to increase the strength of the attachment, and prevent the pin from approaching the surface in thin teeth.

"Fig. 428 is a view of the two-pin bicuspid crown, which affords a pin for each root of a two-rooted bicuspid, the staple form of the pin, shown by dotted lines, being a feature of strength.

"Fig. 429 is a view of a bicuspid crown with the two pins pressed together, making a single pin for the one root.

FIG. 426.

FIG. 427.

FIG. 428.

FIG. 429.

"The double pin in the bicuspid crowns prevents the loosening of these teeth by the rotary movements of mastication, which by means of the two cusps exert such leverage as to turn and break down the ordinary crown where only one pin is used.

"My bridge-work system has the metal baked invisibly through the body of the teeth. No metal shows either inside or outside of the dental arch. The six anterior teeth are riveted to the platino-iridium bar by the ordinary pins of plate teeth, which are the teeth used for this work. The bicuspids and molars are prepared by grinding a slot on the palatal surfaces of the teeth. The bar (which is squared for these teeth, instead of being flattened, as for the front teeth) is inserted into this groove or slot, which should be ground with a thin corundum-

wheel to fit the bar, which can be barbed to make proper impingement. It is then ready to receive the creamy tooth-body, which at this juncture is applied to the palatal surface of all the teeth, completely covering the metal and giving the natural contour to the inner surfaces. A little of the tooth-body is allowed to run between the teeth, uniting their approximal surfaces.

"In this work, when cross-pin teeth are used, the pins will be ground out in most cases; but if straight-pin teeth are used the pins will be bent over the bar. I will give a few illustrations of the many ways in which this work can be done.

"Fig. 430* is a view of a platino-iridium bar baked on to a plain plate tooth, by first riveting the flattened bar on the pins, then applying tooth-body to the back, completely covering bar and pins, and then baking in continuous-gum furnace. The body can be applied readily of a creamy consistence, and after

FIG. 430.

FIG. 431.

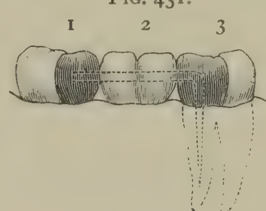
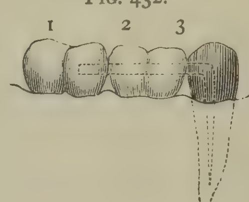


FIG. 432.



being held a moment over a spirit-lamp is ready to be put on the slide and baked.

"Cavities or fillings are usually found on either side of a space made by the loss of a tooth or teeth that will allow the insertion of the ends of the metal bar and the thorough impacting of gold around them. Amalgam can be used in posterior teeth in many cases, or gold crowns penetrated by the bar, as in Figs. 431 and 432.

"In Fig. 431, No. 1 is a third molar, pulp alive, with large

* "Fig. 430 is incorrect in two respects. The palatine aspect of the completed bicuspid should be a curved line from the palatine cusp to the cervico-labial portion, and not make a saddle over the ridge, as shown in the cut, which would be non-cleansible. The other cut, with a bar riveted on to a bicuspid, should have the bar placed in a groove ground into the center of the tooth, riveting being done to incisors and cuspids only."

filling; No. 2 is a porcelain bridge; No. 3 is a first molar, pulp dead, with a metal bar entering the pulp cavity.

"In Fig. 432, No. 1 is a second molar, pulp alive, with the crown filling of gold or amalgam retaining the bar; No. 2 is a porcelain bridge; No. 3 is a gold crown with bar passing through crown into root.

"Fig. 433 is a view of a bridge of two teeth,—a central porcelain crown with a lateral baked into it, the bar and pin being of the same piece, bent at right angles.

"In Fig. 433, No. 1 is a porcelain crown forming part of the bridge; No. 2, a bridged lateral with metal bar baked through it; No. 3, a living cuspid with a metal bar running in the center of a solid gold filling.

FIG. 433.

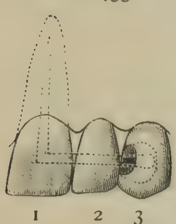


FIG. 434.

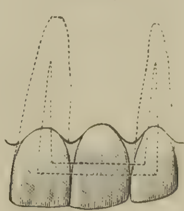
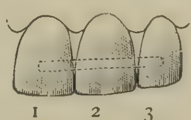


FIG. 435.



"Fig. 434 is a view of a central incisor bridged on to two teeth whose pulps have been lost.

"As many as six teeth have been inserted in this way on two central roots, and the posterior end of the invisible metal bar running through the six teeth worked firmly into a gold filling in a molar—the six teeth being united on their approximal surfaces by the porcelain running between them at the baking. The backs of such teeth must be given a curved form to insure a cleanly condition.

"Fig. 435 is a view of the attachment of the bridge to a tooth standing alone, where the tooth has a gold crown attached, or the bar is worked into a filling. Nos. 1 and 3 are teeth on a porcelain bridge; No. 2 the natural tooth over which the bridge is saddled.

"All teeth for this bridge-work should be ground so that no considerable portion of gum would be covered, the teeth just touching the gum by a point only at the cervico-labial portion."

REMOVABLE BRIDGE-DENTURES.

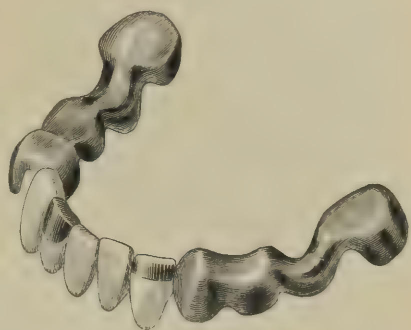
Dr. Dexter's Method.—Dr. James E. Dexter, in a paper read before the First District Dental Society of New York, exhibited models and submitted descriptions of an appliance which he denominated the "Cap Plate," which is removable from the mouth. This mode of substitution, which it has been claimed was tried in England twenty years ago and abandoned as injurious to the teeth capped, is intended to obviate the objections which Dr. Dexter strenuously asserts attach to the ordinary forms of bridge-work permanently fixed in the mouth. Space will admit of only such parts of the paper as relate to the mechanical construction of the appliance.

"Leaving now bridge-work, let me speak of cases in which we could (and often do) wish for some method of inserting artificial substitutes other than ordinary plate-work. Take a case where, on the lower jaw, there are standing in the mouth a third molar, a canine, and first bicuspid, on each side—six teeth in all. These teeth are shortened, by breakage and mastication, so that the upper incisors close to within an eighth of an inch of the gum line between the canines; added to this, they are so tipped and twisted in their places as to make it very difficult to properly adapt an ordinary denture to the space between them; and, lastly, let the patient evince entire abhorrence of, and a fixed resolution not to permit, the resting or pressure of any appliance upon his gum tissues. Such a case is the one for which I have constructed this cap-plate. Such cases are often treated by building up or down the natural teeth with gold, in order to open the bite, and then replacing the lost teeth with an ordinary plate. My apparatus, however, accomplishes both these desiderata in one operation, while simultaneously avoiding any and all pressure upon or irritation of the gum.

"The appliance which I now show you (Fig. 436) is constructed

as follows: Caps of gold and platinum alloy, of about Nos. 26 to 28 U. S. standard gauge, are struck up to fit over and down the sides of the natural teeth selected for the piers, fitting closely. If all the supporting teeth stand perpendicularly and parallel with each other, thus creating no 'under-cut' (so to say), the sides of the caps may encircle the teeth as far as possible (*not*, however, impinging upon the gum line), and be simply slit (in two or more places on each tooth) perpendicularly, so as to spring apart and allow of sliding the whole over the natural convexities of the teeth, the sides coming together again when in place, and thus holding the whole apparatus firmly. But should the teeth be tipped or leaning, and not parallel, the sides of the caps must then extend over only such parts as can be closely fitted, and yet be sufficiently perpendicular and parallel to allow of removal and replacing of the appliance. Of such a character is the case now shown you, there being only one place on the six caps where a *slit* is of value; the sides of the caps being so fitted as to hold partly by their own elasticity, and partly by that of the whole apparatus. Such a case, of course, will most severely try the capabilities of any artificial denture; and not the least merit of the present piece is its triumph over, and perfect and *practical* adaptation to, the obstacles of an exceptionally difficult case.

FIG. 436.



"The caps, when struck up, will not cling to the teeth when in place; nor should they, for they must be capable of easy removal during succeeding processes. But when the piece is ready for final insertion, the sides of the caps must be *sprung inward* sufficiently to hold their supports with firmness.

"The caps being now made, it is in order to determine the length of 'bite' needed. Place the caps in position in the mouth, and build wax on their grinding surfaces to a proper length and

contour, both side and grinding. Invest, remove wax, and flow into its place eighteen-carat gold. Shape the grinding surfaces, by trial in an articulator or the mouth, to the proper occlusion. Next, take an impression with the caps in place, pour the model, select and back plain plate-teeth, and wax them in place. Invest the whole, remove the wax from the backs of the teeth, and fit in the spaces between the caps, bands, or bars of irido-platinum alloy (or gold, as circumstances may determine), being careful that the bars fit *accurately* to the *backings* of the porcelain teeth and to the *caps* at each end. In fitting the bars to the caps, select such points of attachment as will not interfere with the *spring* of the slit sides of the caps. If necessary, let the bars avoid the *sides* of the caps, and reach, by curving, to the *tops* or grinding surfaces. Should you desire to arrange the porcelain teeth irregularly, you need not hesitate to do so. Set them just as you would for rubber or celluloid, and then, simply taking a 'finger impression' of their backs with modeling composition or wax, when invested as above stated, and making dies, you can readily 'strike up' your bars to fit the irregular positions of the backings. But should this be difficult, on account of great irregularity or stiffness of bars, construct the bars of two or three thicknesses of metal, each struck up separately, and 'sweated' into one. Next, solder the bars to the backed teeth, but *not* to the caps as yet. The reason is that *perfect* adaptation of the bars to the caps is absolutely necessary to the success of the piece. Therefore, now place the caps in place in the mouth, and wax the bars with their attached teeth in the spaces between them, filing, grinding, and adjusting until all is exactly as required. Then (and not until then) take an impression of the whole in place, the apparatus coming away with the plaster. Pour the impression with plaster pumice, and sand, or asbestos (sand is best), carefully remove the impression plaster, invest outside the model with its sustained apparatus, and then solder the caps and bars together. In doing this, as little solder as possible should be used, to prevent warping of the whole. The bars should have a broad, firm hold on the caps; but the contour of their union should be made on the bars *before* they are united to the caps, and *not* by flowing on a body of gold

while uniting the bars and caps sufficient to attain the desired hold and shape of union. On the contrary, the bars should be properly shaped at their ends, and carefully fitted to the surfaces to which they will be attached, when a small amount of solder flowed into the joint will make a perfect union and give all the strength possible. All that now remains to do is to spring or bend slightly inward, as before directed, the sides of the caps so that they may grasp their supporting teeth firmly, yet not too much so, or it will create difficulty in removal or insertion; then finish and polish. Burnishing is generally objectionable, since it gives, in some lights, a *black shine* to the piece, adding greatly to the prominence of the appliance as a part of the view whenever the wearer opens his mouth.

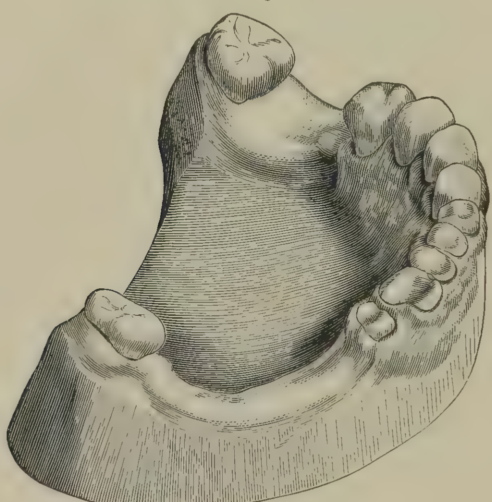
"Should it be desired to produce the best possible results with the piece, the interstices between the artificial teeth and any other crevices to be found may be filled with gold or amalgam —I prefer the former; or vulcanite may be packed in such places (which may be, if necessary, cut out to proper dimensions by burring), and finished up smoothly. The piece shown you contains no less than *seventeen* gold fillings, which signifies that no débris, or even moisture, has any foothold of concealment about it, and that it is, therefore, as clean in itself as is possible for any artificial denture to be. This, you will say, is rather expensive work. Very true. The whole method is expensive in both money and labor. But I am quite consoled for this fact by the thought that it will not, therefore, be likely to do much harm to the public, since the 'cheap-jacks' and 'incompetents' will probably let it alone.

"In the piece shown there are six caps, three on a side. There are five incisor teeth placed between the canines, two of which are capped with gold to break up the uniformity of porcelain in front, as contrasted with the uniformity of gold behind, and thus help to evade artificiality of appearance. Between the molar caps and the double caps for canine and bicuspid, the connecting bar is horizontally placed, dipping downward to parallel the gum line, as well as to evade an encroaching molar above. When necessary, an artificial tooth or teeth can be ground and soldered to these bars. Generally, however, the connecting bars should

be perpendicularly placed, to insure resisting strength in the line of the attacking force.

"Various modifications of this process, as regards its uses, will at once suggest themselves. For instance, where a molar or two on one side are missing, they may be thus artificially replaced without a plate, provided there is a supporting tooth or teeth at each end of the space; or the method may be applied to the treatment of irregularity by capping the molars and bicuspids, or molars alone, connecting the caps of each side together, if necessary, by a band or strap directly across the roof of the

FIG. 437.



mouth, or curving around back of the incisors. To these bands or straps, or to the caps themselves, hooks or buttons for attachment of loops, strings, etc., or threaded nuts for use with screws may be soldered. Should it be desired, for instance, to 'spread' the bicuspid region, place on each pair of these teeth a cap having a socket formed on its inner aspect, and let the ends of a 'Coffin' steel spring rest in these sockets, the force of the spring retaining it in place, and the teeth alone being forced apart without pressure on the gums. This is applicable to a single tooth by making the *opposite* cap enclose teeth enough to resist back

pressure. A large proportion of the gum-irritation usual with treatment of irregularity may be avoided by use of the cap-plate instead of ordinary plates.

"Should it be desired to use the cap-plate where it is not advisable to open the bite, the caps may be struck and fitted as before directed, and then be *cut through and away only at the points of occlusion*, leaving the balance as before. In doing this, however, be sure to leave enough grinding surface to the caps to securely fasten the spring-sides together.

"This method is eminently applicable to cases where *roots only* remain in the mouth—provided they are sufficient in number and strength to sustain mastication. The variation of the process here required is simple. Pivot or ferrule permanently the roots by any proper process (the Büttner method is the best in this case, because the strongest); but, instead of mounting *porcelain teeth* on the pivots or ferrules, fit thereon *gold piers* or stumps of a proper shape (parallel-sided) to receive the caps; and when all the roots are so mounted, proceed exactly as though the metal piers were so many natural teeth,—capping them as such (letting the caps assume the form and size of teeth), and fitting connecting bars and porcelain teeth into the interspaces. Root-cases should be exceptionally favorable ones for this method, since the piers can be placed exactly perpendicular to each other, and be so shaped as to secure for the caps the best of anchorage and bearing.

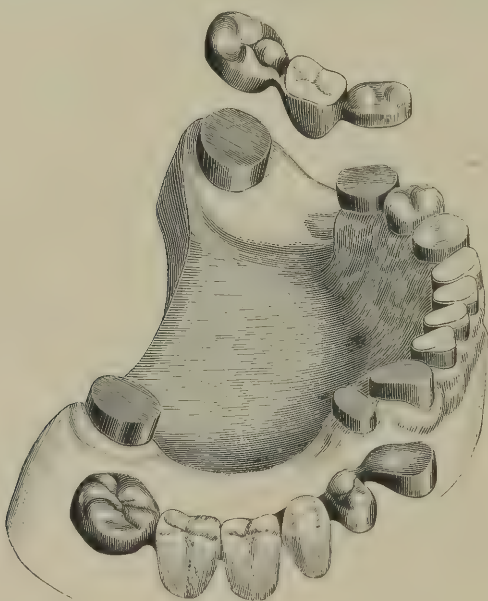
Dr. Starr's Methods.—The following description of his methods in detachable bridge-work is given by Dr. R. Walter Starr:—

"The case of Mr. W. presented difficulties of an unusual character, as may be seen by inspecting the illustration, Fig. 437, which renders detailed description unnecessary.

"It will be observed that the molars and the left second biscuspid overhang to a degree that would make the taking of an accurate impression by ordinary methods well-nigh impossible. After a careful study of the case, it was decided that two separate pieces of removal bridge-work should be attempted, and, as an essential preliminary step, the overhanging sides of the molars and bicuspids were ground with engine corundum-wheels

and points until those sides were made much less inclined, when plaster impressions were taken, first of one-half, and then of the other half, of the jaw. Gold cap crowns were closely fitted over the molars, left second bicuspid, right first bicuspid, and cuspid stump. Gold crowns were made to telescope over all the caps, which were then, by means of oxyphosphate cement, fixed firmly on the teeth. Suitable plate-teeth were selected, fitted, backed, and waxed in place between the telescoping crowns. After

FIG. 438.

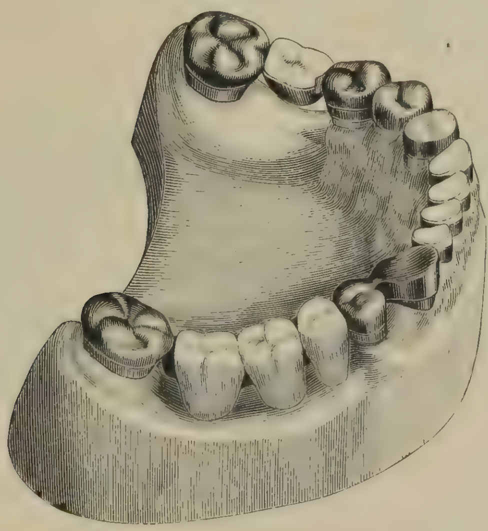


hardening the wax with cold water from a tooth-syringe, the pieces were carefully removed, invested, and soldered. The two completed bridges were easily replaced on or removed from the supporting capped teeth, and their appearance when detached is correctly shown by the illustration, Fig. 438, which also shows the capped teeth and stumps. This figure likewise shows the results of the novel method employed in crowning the incisors. Gold collars were fitted tight on the necks of the incisor stumps, and the new style porcelain caps adjusted in the collars, and set

in the oxyphosphate cement which had been packed into the collars; thus at the same time fastening the collars on the stumps and the caps in the collars.

"Fig. 439 illustrates the finished crowns and bridges, which latter were secured in position by placing a small piece of gutta-percha in each of the telescoping cap-crowns, which were then warmed and carefully pressed in place—the gutta-percha filling

FIG. 439.



only the spaces between the flat tops of the caps of the natural teeth and cuspid caps of the bridges.

"Whenever, for repair or for any other purpose, it shall become desirable to remove one of the bridges, that may readily be done by applying a hot instrument or hot air to the caps to soften the gutta-percha sufficiently to permit the telescoping bridge to be taken off.

"A full upper vulcanite denture was made to replace the old one, which, by improper occlusion, had thrown the full force of mastication on the anterior teeth of the lower jaw, and produced

the destructive action that resulted in the deplorable loss of tooth-substance shown in Fig. 437."*

The next case also presented unusual difficulties. "The forward overhang of the inferior right second molar was so excessive that an impression could hardly be taken, until with corundum-wheels and points the sides of the tooth had been made parallel, or, rather, slightly tapering, to form a truncated cone, with the neck as a base. The molar was alive and sound, but the crown was gone from the pulpless cuspid, which I suitably shaped by means of my root-trimmers (Fig. 440).

FIG. 440.

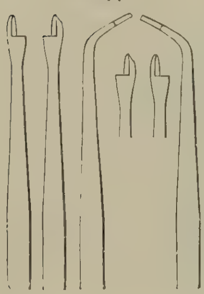
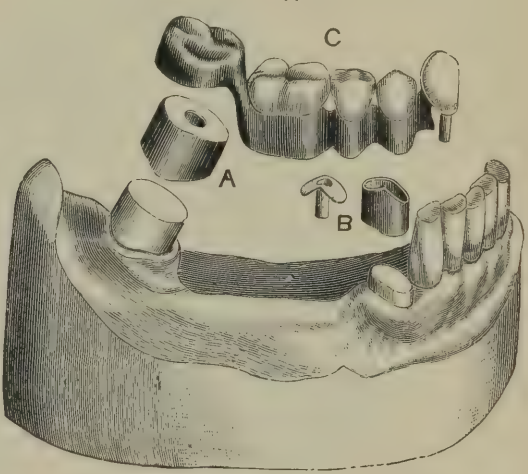


FIG. 441.

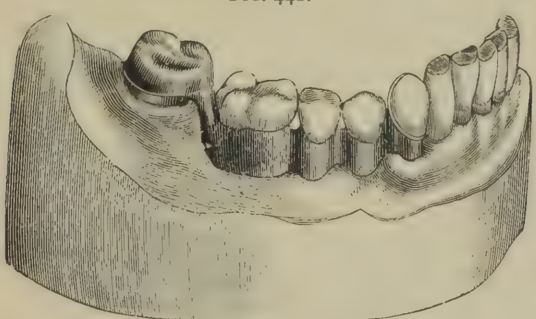


"An impression was then taken, the cast from which is illustrated by Fig. 441. A seamless gold collar was, by means of a slightly tapering mandrel, made to exactly fit the tapered natural molar, the lower edge of the collar cut to conform to the gingival margin, a cap piece of gold plate soldered to the top edge of the collar, and a hole drilled through the center of the completed cap (A). Care was taken to so fit and proportion the cap that it would require finally pretty hard driving to send it home on the tooth; but first there was fitted to the cap a tele-

* *Dental Cosmos*, vol. XXVIII, No. 1, page 17.

scoping seamless collar, on which was soldered a gold plate, with cusps, to form a molar crown as shown. The molar was then thoroughly dried, slightly painted with agate cement, and the cap, A, driven hard down with a flat pine stick held upon it and struck with a mallet, the hole in the cap enabling me to see when the cap was quite down. The cuspid was then likewise fitted with a seamless gold collar, the top edge of which was given a roof-shape, as seen above the root in Fig. 441. A piece of gold received a corresponding roof-shape, had a short section of gold tubing soldered into it, and was trimmed to the outline of the collar, beside which, B, its form is seen, and to which it was subsequently soldered, after suitable investment to keep the

FIG. 442.



parts in proper place. The root-canal had been previously prepared to receive the tube, which, with its roofed cap, was with stick and mallet driven hard down over the root. A piece of gold wire exactly fitting the tube had a roof-shaped piece of properly perforated gold plate slipped over it into position on the root; became fixed in such relation by a drop of melted hard wax; was removed, invested, soldered, and finished in such shape that, excepting the hollowness, it looked like the tube and cap B.

"The relations of the occluding teeth had, of course, been determined by an articulating model, and by means of it a series of seamless gold collars and cusp-crowns were adjusted on a thin platinum plate fitted on the cast between the cuspid and second molar, and the collars soldered to the plate after invest-

ment. The truss thus formed received an appropriate finish by the rounding and smoothing of its basal borders. A plain plate cuspid was backed with gold plate and fitted on the roof-plate, to which, after determining its proper occlusion, it was secured by hard wax, removed, invested, and soldered. It was then put into the tube on the root, the telescoping cap put over the molar, the truss put in position in the mouth, and the whole covered with plaster and marble-dust, contained in a suitable sectional impression-tray, which enabled me to hold the mass steadily in place until the mixture was sufficiently hard to bring away cap and truss and roof-plate all in proper position. A second mixture of plaster and marble-dust, and a suitable trimming of the first mixture after all was hard, sufficed for the soldering process that resulted in the denture which, when finished, appeared as shown detached at C, Fig. 441, and mounted on the cast in Fig. 442. It went firmly to place in the mouth, and yet was removable in the possible event of accident to the denture, or for readjustment of the cusp-crowns, which latter could easily be done by warming the piece sufficiently to soften the gutta-percha, replacing the denture on its anchorages, and directing the proper closure of the occluding teeth."

Dr. Parr's Method.—The following is Dr. H. A. Parr's method of constructing removable bridge dentures. In describing it* the Doctor says:—

In the construction, adjustment, and placing of a dental substitute, one of the first considerations is its immovability in position, and next its removability for cleansing or repair. The old styles of clasp-dentures met these two essential requirements when the forms and relations of the supporting teeth were such that the clasps would firmly embrace those natural teeth and hold the close-fitting plates in position. But the clasped teeth soon became worn or wasted, and in consequence the loose denture lost its efficiency. Even in favorable cases the inverted cone shape of nearly every natural tooth made it a matter of difficulty to secure at the neck near the gum a tight fit of the springy clasp, which, in every instance, must have been large

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* *Dental Cosmos*, vol. XXXI, page 172.

enough to go over the crown of the supporting tooth. Then, too, there was the tendency of the plate to press into the gum and so become loose by carrying the clasp to a yet narrower place on the tooth. In many cases, moreover, the supporting teeth inclined toward or away from each other, and made it well-nigh impossible to construct a plate which could be sprung into place and yet so tightly clasp the teeth as to firmly hold the denture in position.

The object in devising the method of attachment and organization of dental substitutes now to be explained was to avoid the difficulties mentioned, as will be made evident in the following description of two practical cases.

Fig. 443.

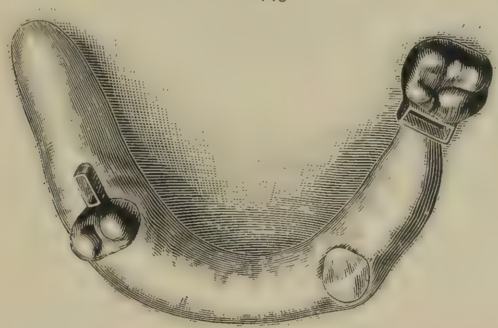
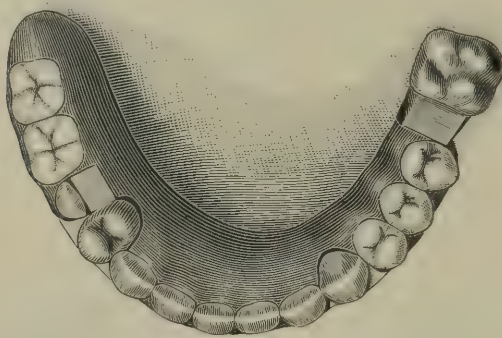


Fig. 443 is from the plaster cast of a lower jaw in which only the lower left second molar, cuspid, and right first bicuspid remained. The molar and bicuspid were fitted with gold cap-crowns. Gold sockets were prepared, and gold tongues, made of strips of spring gold plate having their ends folded upon themselves to form spring catches, were fitted to the sockets. The cap-crowns were placed on the plaster teeth, the boxes or sockets hard waxed to the sides of the crowns, and the tongues hard waxed to a piece of stiff wire so that the two tongues could be lifted out of their sockets without breaking either the tongues from the wire or the sockets from the crowns. When by repeated trials this could be done, the crowns and sockets were taken from the cast, invested in plaster and marble-dust, and the

sockets soldered to the crowns. These were replaced upon the cast and appeared as seen in Fig. 443.

The tongues were then placed in the sockets, the artificial teeth arranged on the cast and waxed up as usual for vulcanite

FIG. 444.



work, taking care that the projecting ends of the tongues were so embedded in the wax that they would be held firmly when the piece should be removed to be flasked. It is, in fact, best that at the outset the tongues should be soldered to a stout gold wire bent to fit the cast, so that the wire will stiffen the waxed-

FIG. 445.

up piece, and also hold the tongues more securely in the piece during and after vulcanization.

Fig. 444 shows the vulcanized denture in place on the cast.

The underside of the denture is shown in Fig. 445, which also makes evident the forms and relations of the tongues which hold

the denture in place. The parallelism of the tongues permits their ready removal from their sockets, no matter how much awry the supporting teeth may be. The bearing of the denture upon the cap-crowns admits of the contact of the denture with the gum on which it rests but cannot be pressed into because of the cap-crown supports. The original denture of which this is a duplicate is now in satisfactory use.

Fig. 446.

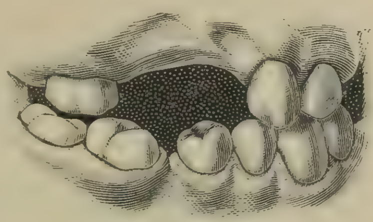


Fig. 447.

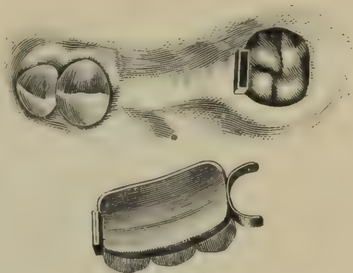
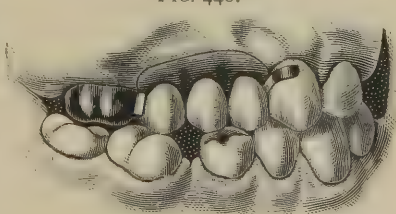


Fig. 446 represents the articulated cast of a case for which a similar tongue and clasp vulcanite denture was made. This is illustrated in Fig. 447, which needs no description. Fig. 448 shows the denture in place, the original having been made for and placed in the mouth of a patient exhibited at the clinic of the Odontological Society of Pennsylvania, at Philadelphia, in December, 1888.

These are simple examples of a class of work having a wide range of application and capable of construction without the trouble and cost of all-gold plate-work.

The sockets and spring tongues require some skill and nicety of workmanship to insure a close fit of the one in the other so that the attachment shall be firm, yet capable of easy-designed detachment for cleansing or repair.

Fig. 448.



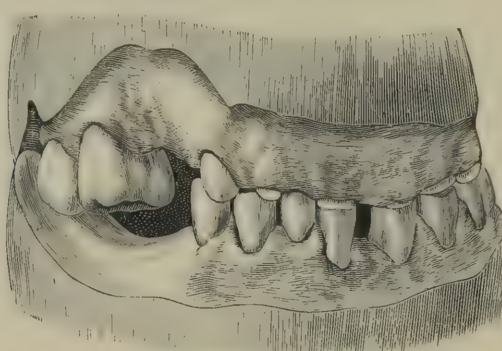
A notable advantage of this mode of constructing dentures for the upper jaw is manifest in the fact that the surface of the plate which rests upon the gums need only be wide enough to cover the ridge, and thus

avoid the quite too common interference of artificial dentures with the functions of taste and speech.

Dr. Davenport's Method.—The following method of constructing partial dentures, described by Dr. J. L. Davenport in the *Dental Cosmos*, is an amplification of the principle of attachment involved in the process just considered.

The case treated by Dr. D. was one where the only teeth remaining in the upper jaw were the six front teeth, the three molars on the right side, and the first bicuspid on the left. The crowns of the front teeth were wholly obliterated from excessive attrition consequent on the loss of the occluding back teeth

FIG. 449.



necessitating the exclusive use of the former in mastication, as shown in Fig. 449. The shortening of the lower teeth, resulting from the same cause, was remedied by building them up to a uniform height with crystal gold, Fig. 453, the vacuities in the lower jaw resulting from the loss of the left central incisor and several of the back teeth being supplied with substitutes in the manner hereinafter described.

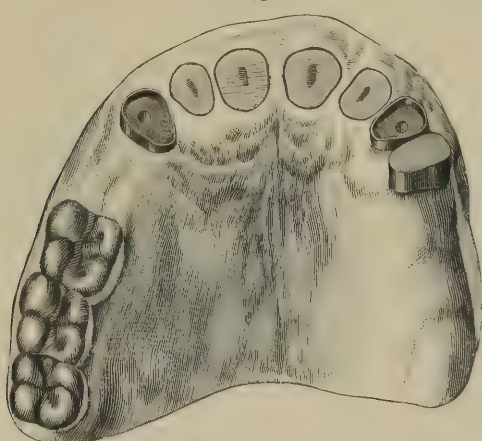
For this case what is termed a "Combination Plate and Movable Bridge" was constructed, and is thus described:—

"The two superior cuspid roots were dressed down nearly to the gum, and fitted with 22-carat gold cap-crowns, similar to those described by Dr. J. Rollo Knapp. After these had been placed in position, a hole was drilled through each cap of a size

suited to that of the pulp canal, and a tube of iridium and platinum was adjusted in the root cap and waxed in position. The cap and tube were then taken off and soldered, great care being taken to have the tubes enter both roots perfectly parallel. These were permanently secured in the roots with gutta-percha, and to prevent the caps being pulled off, the top of each tube was slit down a trifle, and after insertion was bent back into the gutta-percha with a warm instrument.

"The incisor roots having been dressed down even with the gum and filled, a plaster cast was taken and a narrow 20-carat

FIG. 450.



gold plate was swaged to fit over the ends of the incisors and the capped cuspids, making it a little broader where it had to rest on the gum back of the first left bicuspid root. A hole in the plate was then made to expose the root of the first left bicuspid. This was fitted with a bifurcated iridio-platinum pin, having notched sides, and a hammered head upon its lower end, which came down below the root about three-eighths of an inch.

"A thin iridio-platinum band was then made to encircle the root, passing just under the gum and being slightly longer than the headed pin. This band was perforated with two rows of holes, from without inward, giving the inner surface a roughness similar to that of a nutmeg-grater. The band and pin were

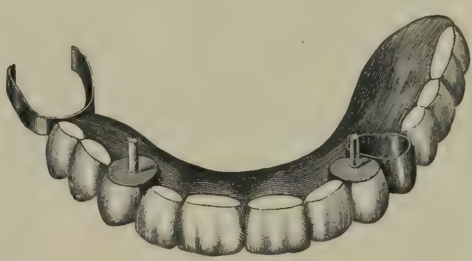
then made secure to the root with a non-shrinkable copper amalgam.

"Fig. 450 shows the upper jaw ready for the plate.

"I must mention here that this method of lengthening the bicuspid is not original with me, but has been previously described by Dr. E. Parmly Brown. I have, however, used this method several times on very frail roots, and cemented over the entire a gold cap-crown.

"In the present case, after the amalgam had become hard and the end and sides had been polished, a gold crown was fitted over all just up to the margin of the gum, and in close contact with the end of the band and amalgam. This crown was loose enough to admit of its sliding on and off, though with just

FIG. 451.



enough friction to hold it in place when at rest. This gold crown was then placed in position, the plate also inserted, and hard wax used to firmly join the two in the mouth. They were then removed and soldered.

"Gold pins were then placed through holes drilled in the plate into the tubed cuspids; then soldered to the plate, the pins being of a size to fit the tubes accurately. The plate was also provided with a wide clasp encircling the first molar on the right.

"The plate was then provided with a gold bar about one-eighth of an inch wide, occluding perfectly with the lower teeth, and plain teeth soldered in place, hiding the bar, and just meeting the gum in front of the incisor roots. The plate rested squarely against the capped cuspids, each of which showed a narrow band

of gold when the plate was in position. As finally completed (see Fig. 451), this was the most perfectly-fitting piece I ever inserted, requiring great care in its removal, and yet by a little practice the gentleman was able to remove and replace it quite easily. It was also as firm as any permanent bridge could have been, though it had no support on the left side back of the first bicuspid.

"The lower jaw was supplied with a double 20-carat gold plate. having a wide clasp on the first right bicuspid, which, after being built up, presented a cone-shaped top, about which the clasp

FIG. 452.

fitted so as to rest firmly upon the end of the tooth, thus preventing injury to the gums during mastication.

"The only other peculiarity was that the second left inferior molar, being abnormally short, though well-formed and standing upright, was fitted with a wide clasp, extending about one-eighth of an inch about the tooth, and a piece of gold plate with gold cusps was soldered into its clasp, covering the molar crown, and occluding with the molar on the upper plate. (See Fig. 452). This not only prevented the plate from being bitten down unpleasantly on the gums during mastication, but enabled me to use a shorter molar upon the upper than I otherwise could have done, and better allowed the antero-posterior and lateral movements of the jaws.

"Fig. 453 shows the case as completed."

The Mandrel System.—The following description of "A Sys-

tem of Crown- and Bridge-work" is given by the experts of the S. S. White Manufacturing Co., who have designated it as "The Mandrel System."

"An examination of a large number of human teeth shows that, no matter how great differences may exist in the apparent shapes of the crowns of individual teeth of a given class, there is a remarkable uniformity in the configuration of their necks. That is, the necks of upper cuspids, for instance, were found to have a fixed type, from which the variations were very slight as to shape, though there appeared to be no exact standard of size. So of the other classes, with the single exception of the superior

Fig. 453.

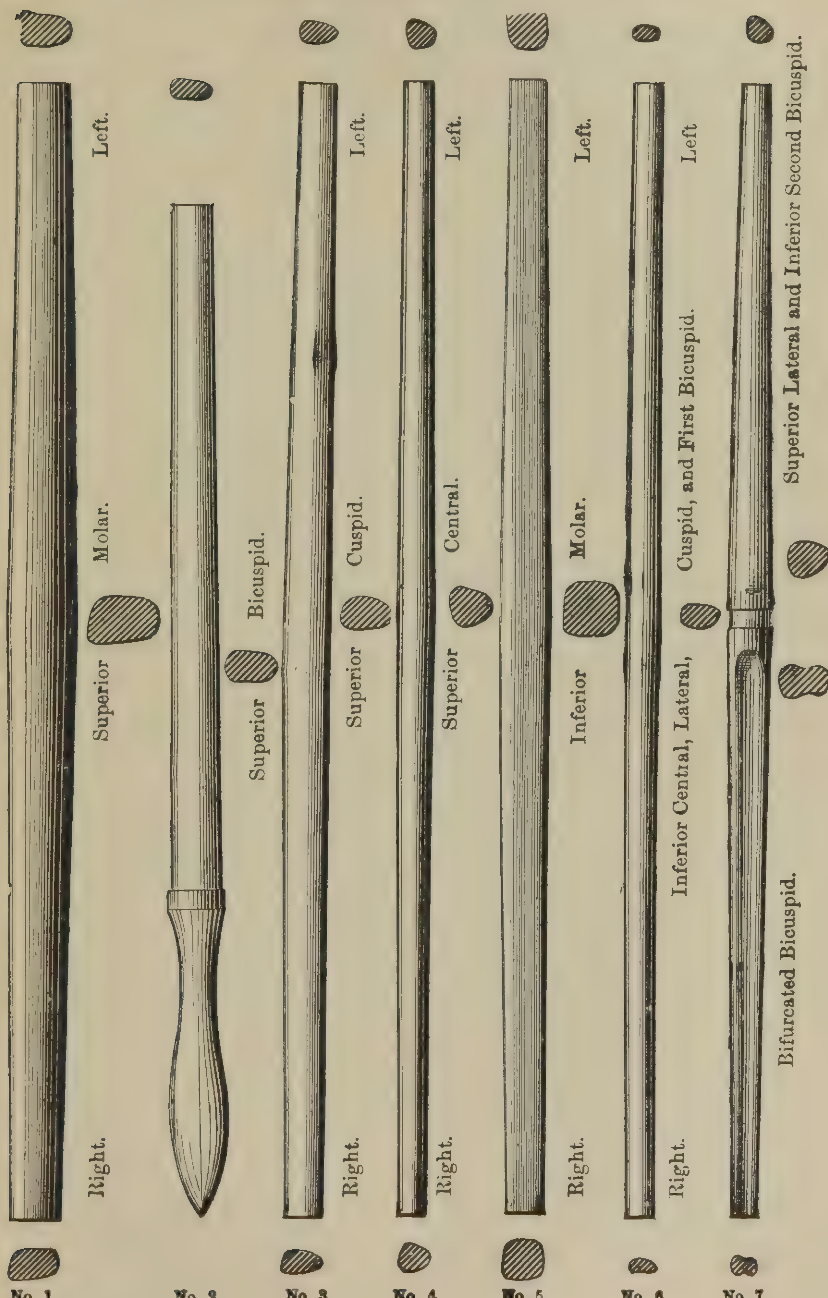
molars, in which two distinct forms were found, the first being those in which the buccal roots were wider than the palatal; the second, those in which the reverse condition was found, the single palatal root being wider at its junction with the crown than the two buccal roots. The occurrence of roots of the second class being rather exceptional, the first class was accepted as the type.

"The configuration of the necks of all the teeth having been determined, a set of mandrels for shaping collars to fit them was devised. The set (Fig. 454) consists of seven mandrels, six of which are double end. Their shapes are modeled upon the general typal forms of the necks of the teeth which they represent, and they are made tapering to provide for all required

Fig. 454.

MANDRELS

FOR SHAPING SEAMLESS TOOTH-ROOT COLLARS.



variations in size. The illustrations are about two-thirds actual size, the longest instruments being nine inches in length. The cross-sections show the shapes and proportionate sizes at the greatest and least diameters. The long taper permits the most minutely accurate adjustment of the collars.

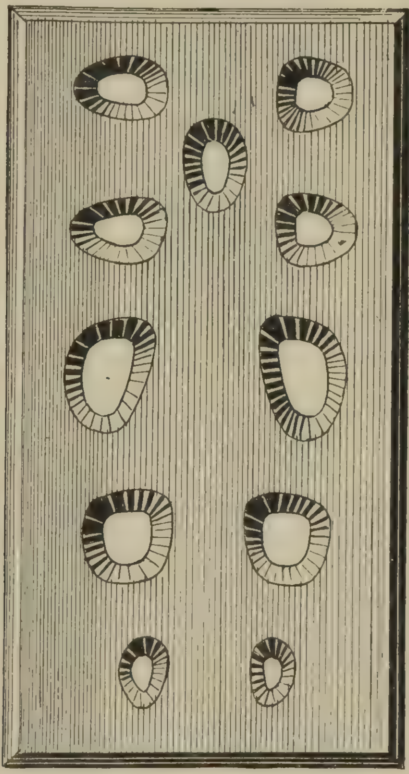
"No. 1 is a double-end mandrel, for superior molars, right and left; No. 2 is a single mandrel, for superior bicuspids, right and left; No. 3 is a double-end, for superior cuspids, right and left; No. 4, double-end, for superior centrals, right and left; No. 5, double-end, for inferior molars, right and left; No. 6, double-end, for the inferior centrals, laterals, cuspids, and first bicuspids, right and left; No. 7, double-end, one end for the superior lateral incisors, the other for those bicuspids in which a bifurcation of the roots, or a tendency in that direction, extends across the neck to the crown in the form of a depression on one or both approximal surfaces. The foregoing scheme comprehends all the teeth of the permanent set except the second inferior bicuspids. The necks of these approximate those of the superior central incisors so closely in shape that it was deemed inexpedient to make a separate mandrel, as the No. 4 mandrel will serve for both.

"The collars or bands are made seamless, of No. 30 (American gauge) gold plate, 22 carats fine. Fifteen sizes, each of three widths ($\frac{1}{10}$, $\frac{2}{10}$, and $\frac{3}{10}$ inch) are made (Fig. 456), which it is believed will cover all requirements. These collars, although devised as a part of the system, can be used in all methods of crown- and bridge-work which require bands, and possess many advantages over any others. They are really labor-saving devices, as their use saves the time and trouble of making, and there is no danger of their coming unsoldered when the pins or the backing of the crown are being soldered; and there are no hard spots to give trouble in burnishing, as, for instance, close to the root, after the collar has been shaped and placed in position, the whole surface being uniformly soft.

"The seamless collars are also especially adapted to removable or detachable bridge-work. They are so constructed that Nos. 1, 16, and 31 exactly fit into or telescope with Nos. 2, 17, and 32, and so on through the entire set, each collar fits into the series next higher; so that a root may be banded with one size

and the size next larger used to form the tube for the telescoping crown. When desirable, the 'seamless' collar can be strengthened, after it has been adapted to the conformation of the crown so as to slide freely over it, by investing and flowing solder over the outer surface; or, still better, by adapting the next larger

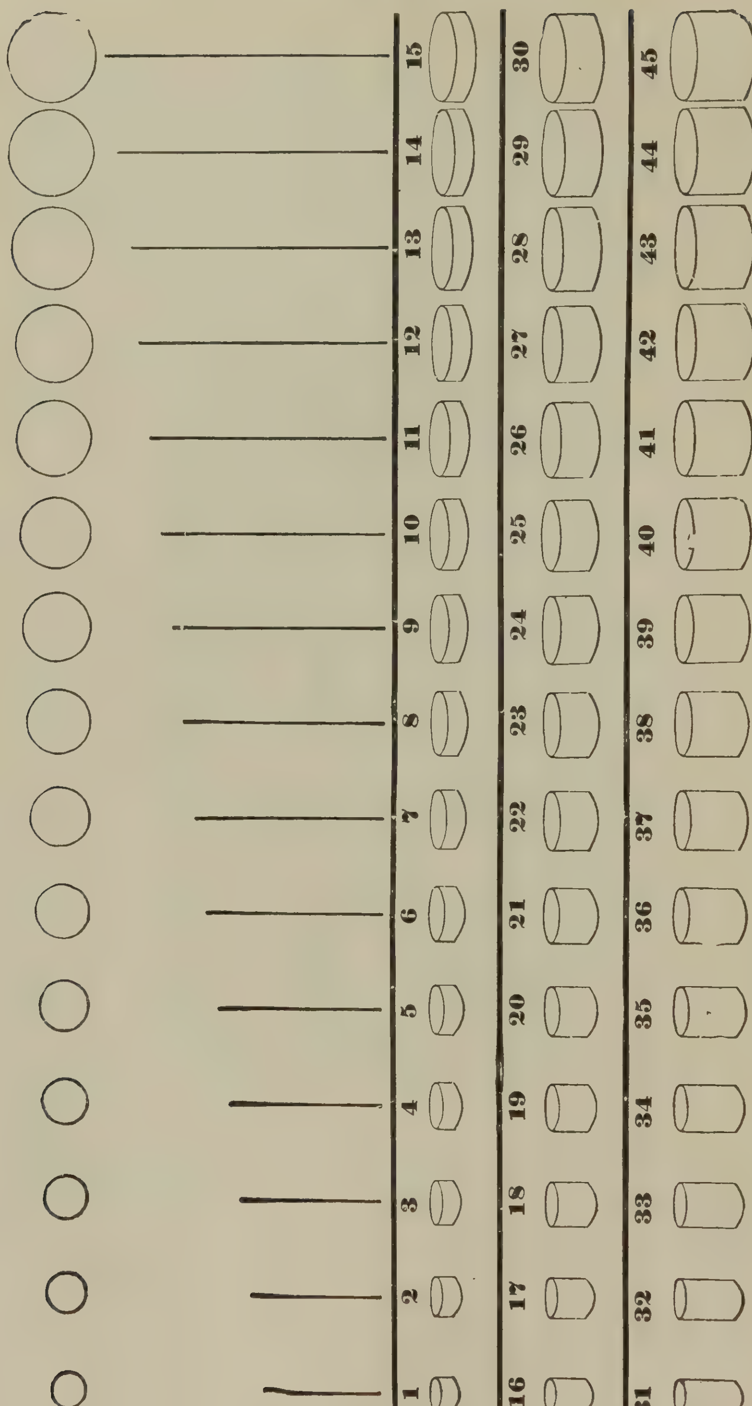
FIG. 455.



size of collar to exactly fit around the first, and then investing the two and soldering them together. The advantages of these collars for this kind of work, and also for the construction of cap-crowns, are obvious.

"The other appliances specially devised for this system are, a reducing plate or contractor, a pair of collar pliers, and a hammer.

Fig. 456.



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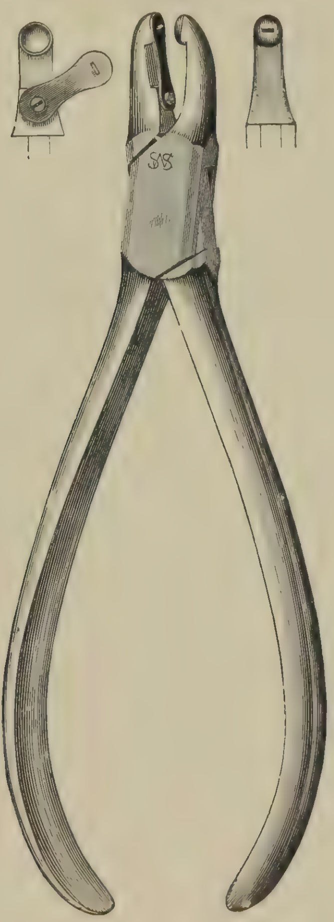
"The contractor (Fig. 455) contains holes which are complementary in shape to the mandrels. The mandrels being applied to the inner circumferences of the collars, while the contractor must admit the collars themselves, the short taper of the holes

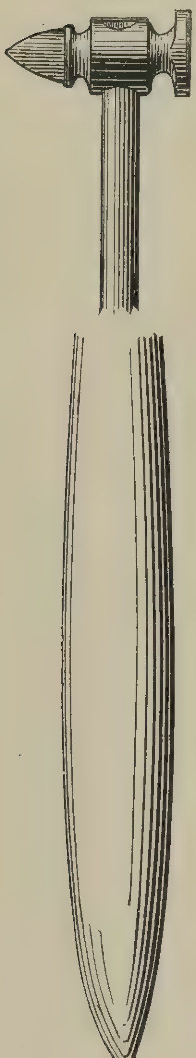
FIG. 457.



in the contractor necessarily covers a somewhat greater range of size than is shown in the mandrels. With this appliance collars can be evenly and accurately reduced in size at the edges, without burring or buckling. The illustration is actual size.

"The collar pliers (Fig. 457) are for contouring the collars to shape, one beak being made convex and the other concave to correspond. With this appliance the slightest changes required in the contour of the collars are easily made. About a half-inch from the extremity of the concave beak a small bar of flat steel is attached to it by means of a screw. The free end of the bar has a minute projection upon one face, the other being reinforced to fit into the concavity of the beak. In the center of the face of the convex beak is a depression, into which the projection on the steel bar strikes, making a very efficient punch for forming guards or stops to prevent the collars from being forced too far under the gum. The depression in the convex beak being slightly larger than the projection or punch, the metal is not cut through, but merely raised on the side opposite to the punch. The punch attachment being pivoted can be swung to one side when not in use.

Fig. 458.



"Fig. 458 is a mallet or hammer, with steel face and horn peen. The handle is nine inches long.

"One of the appliances required is a lead anvil, which being only a piece of soft lead, say two by three inches, and an inch thick, is not illustrated. The counter-die of an ordinary case will answer very well.

"To illustrate the uses of these appliances, take a case in which the two inferior bicuspids of the left side are missing, and the crowns of the cuspid and first molar so badly decayed that the probabilities are that they will soon fall victims to the forceps. The old-time way would have been to extract the molar and cuspid, and make a partial plate. Examination, however, shows that the roots of these two teeth are in good condition, afford-

ing an excellent opportunity for the construction of a piece of bridge-work.

"With a corundum stone, cut off the remaining portions of the crowns level with the gum margins. Prepare the roots in any of the well-known ways, thoroughly cleansing the apical portions and filling them with whatever material is desired, being careful only that the work is well done. For the better retention of the filling material to be placed in the pulp-chamber, retaining-grooves can be made or retaining-posts inserted. Take a piece of binding-wire (No. 26, American gauge), say $2\frac{1}{2}$ inches long, pass it around the neck of the molar stump, cross the free ends, and, holding the wire in place with one finger, twist the ends with a pair of flat-nosed pliers until the wire clasps the tooth closely at every point (Fig. 459). When there are any irregularities in the contour of the tooth, it is necessary to press the wire into them with an approximal burnisher. It is obvious that the ring thus formed will show the exact size and shape of the neck of the tooth. Remove the ring carefully, lay it on the lead anvil, put over it a piece of flat metal, and with a smart blow from a hammer drive the wire into the lead (Fig. 460). Upon removing the wire an exact impression of the ring will be left in the lead anvil. (This part of the work, as indeed all others, should be done carefully as described. The wire ring may be driven into the lead by a direct blow of the hammer face, but the blow might not strike equally, and the interposition of the flat metal held level insures an even impression. A piece of an old file is best, as the file-cuts keep the wire from slipping.)

"Next, cut the wire ring at the lap, straighten out the wire, and select a suitable collar by comparing the length of the wire with the straight lines in the diagram, which show the inside diameters of the various sizes. Should none of these correspond exactly, take preferably the next size smaller. It will be remembered that the collars are No. 30 in thickness, while the wire with which the conformation is secured is No. 26. This difference permits the collar when contoured to shape to enter the lead impression readily, a decided advantage in fitting. Having selected the collar, fit it to mandrel No. 5, with the peen of the hammer, holding it upon the lead anvil, and using a slight push-

ing force to help in stretching and forming it (Fig. 461). Having driven the collar to form, remove it from the mandrel and try in the lead impression. If it does not fit exactly return it to the mandrel and stretch it a little, when it will usually fit perfectly, as the mandrels have been designed carefully to the average shapes which obtain in the great majority of tooth-necks. In the exceptional cases where the collar does not fit, it can be readily contoured to the exact shape with a pair of flat-nosed pliers. Of course, if it fits the impression in the lead, it will fit

FIG. 459.

FIG. 460.

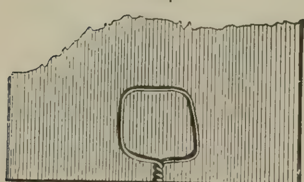
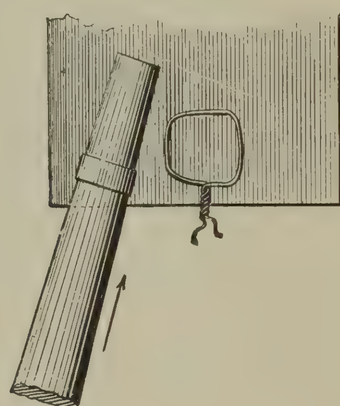


FIG. 461.



the neck of the tooth, always provided the measurement and the impression have been carefully made.

"If the collar or band has been accidentally stretched too much, or if, for any reason, when brought to shape, it is too large, its root end can easily be reduced to the proper size by the use of the contractor. Place the edge of the collar which is to fit in the root in the proper hole; hold it level with a piece of file as in taking the lead impression of the ring, and tapping lightly on the file drive the collar into the plate (Fig. 455) until the proper reduction is made. The collar is next 'festooned' to correspond to the shape of the maxillary ridge. Lay it, gum edge up, on the lead anvil, and with the piece of flat file and the hammer drive it into the lead. A few cuts with a fine half-round

file across the approximal diameter will conform the edges to the surface of the ridge (Fig. 462). Then place the collar in position, and, having ascertained just how far it should go down on the root, remove it, and with the small spring punch in the collar pliers (Fig. 457) form projections on the inside of the band at the proper points to serve as stops which, resting on the top of the root, will prevent the collar from being forced further down upon it than is desirable (Fig. 463).

FIG. 462.

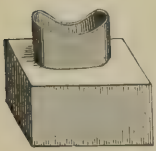


FIG. 463.

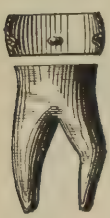


FIG. 464.

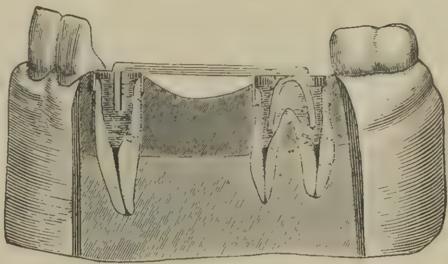
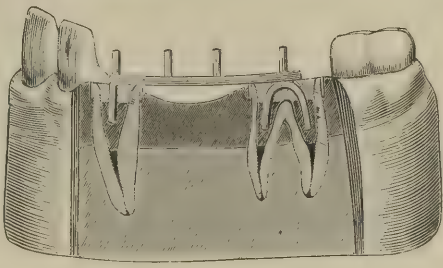


FIG. 465.



"A collar for the cuspid is then fitted in the same manner, using mandrel No. 6 for shaping, after which the case is ready for the building of the bridge.

"Place both collars in position and take an impression of the parts, including the interiors of the excavated pulp-chambers, from which make a cast in the usual way. Bend a short piece of half-round gold or platinum wire into the form of a horseshoe, the two extremities of which shall fit into the roots of the molar. Then take a longer piece of the same wire, somewhat more than enough to extend from the toe of the horseshoe when

in position to the cuspid root; bend one end of it at a right angle, or nearly so, to fit the root of the cuspid, and (cutting off any excess of length) solder the other end to the toe of the horseshoe. The bar extending between the two roots is the truss of the bridge. Next, place the appliance on the cast (Fig. 464), holding it in position with wax, and select the teeth to take the place of the missing bicuspids and molar. The best form for this purpose is a tooth having holes extending through it vertically from the neck to the grinding surface, similar to the well-known Bonwill Crown.

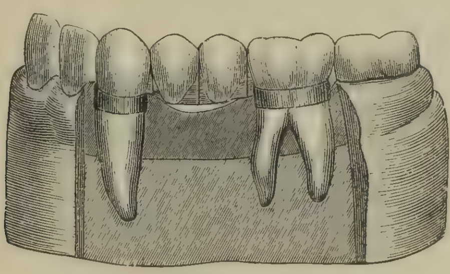
"The crowns used should be large enough to fill the space rather tightly, even if their sides have to be flattened to let them in. If the teeth do not fill the space perfectly, a small portion of plastic filling material crowded between them, as mortar between the granite blocks in the arch of a railway bridge, will greatly increase the strength of the work.

"After the teeth are ground to fit and the proper length for occlusion ascertained, the truss is covered with a film of wax, upon which the crowns are again pressed to their positions. Upon the removal of the crowns the impression of the holes running through them will be found in the wax. At these points drill holes through the bar with a small twist-drill run by the dental engine, and into these fit and solder the pins for the support of the crowns, as shown in Fig. 465.

"The bridge is now ready to be attached permanently. Set the crowns in position upon their supporting pins, to secure the proper alignment. (If the operation were upon the upper jaw they would have to be held with wax.) Put into the canals of the supporting roots (the cuspid and first molar) a sufficient quantity of some quick-setting plastic, as oxyphosphate, to about half-fill the pulp-chamber, but not enough to prevent the supports of the truss from being forced home. Force the bridge supports to place, and after allowing the filling material to become set remove the crowns. Fill the remainder of the pulp-chamber and the whole of the collar with gold, amalgam, gutta-percha, oxyphosphate, or other suitable plastic (Fig. 465). Set the crowns permanently, the molar and cuspid first, as this affords greater facility for the trimming off of any

excess of the filling material used in the attachment. For attachment of the crowns, gutta-percha is probably the best material, as crowns set with it are readily removed for the correction of any inaccuracies of occlusion or alignment, by grasping them between the beaks, previously warmed, of a pair of universal lower molar forceps. The heat warms the gutta-percha and releases the tooth, which can then be reset properly. In attaching crowns with gutta-percha the holes in the crowns are first filled with the material, after which the crown is warmed and forced to place. Any of the other plastics ordinarily used in setting Bonwill crowns can be employed, at the discretion of the operator. Fig. 466 shows the case completed.

FIG. 466.

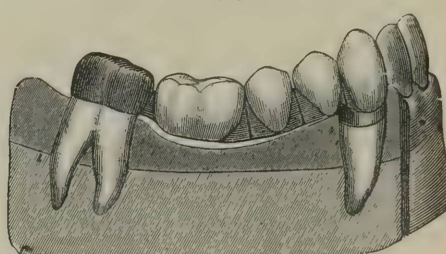


"In securing the occlusion of a piece of bridge-work it is well to make the artificial teeth a little short, so that the natural teeth on both sides will meet the first shock of mastication. Nature will correct the occlusion in time by slightly elongating the roots supporting the bridge. If the artificial crowns are permitted to strike the natural teeth from the first, the undue strain upon the two supporting roots will cause soreness and, perhaps, more serious consequences.

"When a sound tooth is to be used as one of the supports of the bridge, a modification of the method just described is necessary. Take a case where it is desired to bridge the space caused by the loss of the right inferior bicuspids and first molar. The crown of the right cuspid is nearly gone, but the root is sound and capable of supporting one end of the bridge. The other end will be attached to the second molar, which is a sound

tooth. Prepare and band the cuspid root as before, dress off the second molar crown until it is slightly smaller than the neck, so as to permit a cap to be telescoped over it, and take the measure of the crown with the binding wire. Select a suitable seamless collar of sufficient width to extend from the neck to a little beyond the grinding surface and drive it up on the proper mandrel to get the general shape, but not the full size required to fit the tooth, leaving it so that the edge having the larger circumference will just pass over the end of the crown; place the collar on the tooth and with a block of wood and the mallet tap it to place just beyond the free margin of the gum. This method will make a close fit, as the collar will readily stretch all that is necessary. With a sharp-pointed instrument mark the length of

FIG. 467.



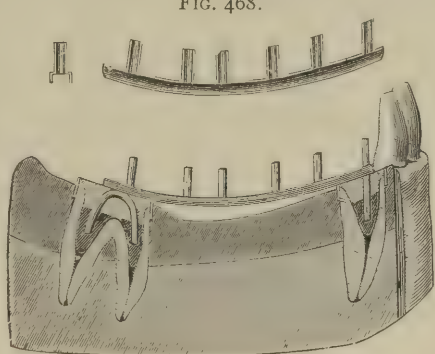
the crown, remove the collar, and cut it to the proper width as indicated. Then in a piece of gold plate of the thickness used for caps form four little depressions of the general character of an impression of the molar cusps. An easy way to do this is to lay the plate on the lead anvil; then with the ball on the end of an ordinary socket-handle and the hammer the depressions are made in a moment. Set the collar on the plate, borax it, charge with solder, and heat till the solder flows. Cut off the surplus plate and a perfect cap for the molar is made. Place it on the tooth and take an impression, and thereafter proceed as before directed to make the truss of the bridge and mount the teeth, except that in this case the posterior end of the truss is to be soldered to the molar cap. For the final attachment place a little oxyphosphate or other plastic filling material in the cap to secure it firmly (Fig. 467), first cutting a slot in the crown end for the escape of the

excess of material. Pressure upon the filling material hastens its hardening.

"**Detachable Bridge-work.**—A description of two or three methods of constructing detachable bridges by the mandrel system, will suffice to indicate the general principles involved. Having these, each operator will find it an easy task to devise the modifications necessary to adapt a method to individual cases.

"The first method is especially applicable to cases where both ends of the bridge are attached to roots, as, for example, the inferior cuspid and second molar roots of the left side, the intervening teeth having been lost. The operation is conducted as described in the first case of fixed bridge-work down to the construction of the truss, for which in this method square gold wire is used. Having cut the wire of the proper length, lay it upon a piece of gold plate (about No. 26, American gauge) of the same length and full three times as wide, and, placing the two upon the lead anvil, with a hammer and the piece of file before used drive them into the lead. This will form the plate into what we may call an open trunk which fits the square wire. Remove the two from the lead together and, without separating them, curve to the proper shape to form the truss. Grind crowns having vertical holes, like the Bonwill, to fit, and having determined the proper points for the supporting pins, drill through both trunk and bar at these points. Separate the bar from the trunk, and fit and solder pins to the bar. Construct small tubes to fit the pins, ream out the holes through the trunk to admit them, and set the tubes with solder in the enlarged holes (Fig. 468). Fix the crowns permanently upon the tubes. They may be mounted in any of the approved ways, by vulcanizing

FIG. 468.

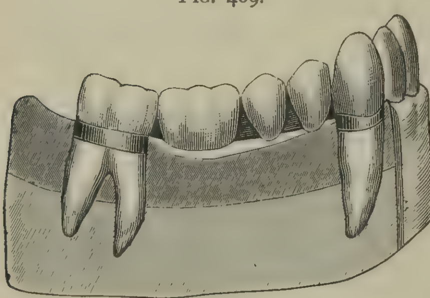


or by the use of a plastic filling material. When they are firmly set, place the trunk with the teeth upon the bar and anchor it permanently as already described. Fig. 469 shows the completed work.

"In this method the truss consists of the bar and the open trunk which covers three sides of it. The bar is, of course, permanently attached to the roots of the molar and cuspid, but the trunk with the teeth can be removed at any time.

"The second method of constructing a detachable bridge is applicable to cases where one or both of the supports or piers are sound teeth. In the case adduced for illustration, the right inferior cuspid crown was decayed, and both of the bicuspids and the first molar were absent. The supports for the bridge were the sound second molar and the cuspid root. After the cuspid root was prepared and banded, the crown of the molar was reduced very slightly, not sufficient to destroy the enamel, but just enough to permit a collar properly fitted to pass over it. A collar somewhat wider than the length of the crown from grinding surface to neck was fitted and cut to the proper width. Two lugs were then soldered upon the anterior and posterior sides and bent to fit into the approximal fissures, which were slightly cut out to admit them. An impression was taken, the collar coming away in the plaster, and a cast was made with the collar in position. A coned tube was then made for the root of the cuspid and a coned pin fitted into it. A truss of half round wire was made to which the collar, coned pin and the molar were next soldered (Fig. 470). A half-clasp to grasp the lateral was next soldered to the end of the truss, to be supported by the cuspid. The object of this clasp was to guard against the teeth being thrown out of proper alignment by the force of mastication. Bonwill crowns were then vulcanized to the truss, after their

Fig. 469.



supporting pins had been fitted and soldered to it. (Counter-sunk crowns can be used as well in the same way. Plain plate teeth may also be used in this style of work, in which event they are to be soldered to the truss.) The bridge was then ready to be set, which was accomplished in the following manner: The cuspid root was nearly filled with oxyphosphate, and the coned tube was placed upon the pin. The band was put on the molar, and the coned pin with the tube upon it was forced into the plastic in the cuspid root. As soon as this became set, the tube was held permanently, while the bridge itself could be removed whenever desired (Fig. 471).

"This method of fixing the tube allows considerable range in

FIG. 470.

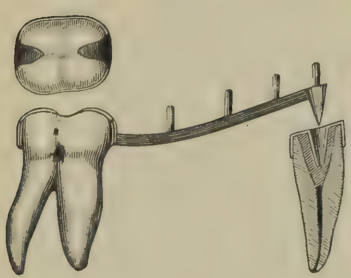
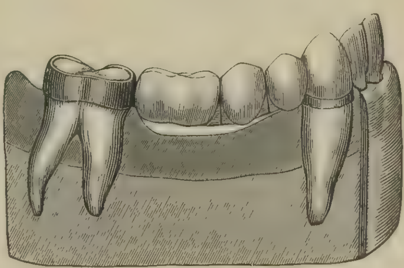


FIG. 471.

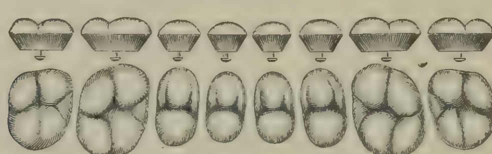


its adjustment. In soldering the coned pin to the truss, care should be taken to set it at an angle exactly parallel to the axis of the molar; otherwise there will be difficulty in removing the bridge.

"The third style of detachable bridge-work to be described involves the use of cusp crowns (Fig. 472) for supporting posts or piers. Suppose a case similar to that described at page 382, where a bridge is required to extend from the right inferior cuspid to the right inferior second molar, with only the roots of the two teeth named as supports. Prepare the roots and pulp-chamber. Set screw-posts into the dentine for anchorage or as retaining pins, and fit the collars, using sizes wide enough to form the walls of the crowns. Fill the pulp-chamber and about two-thirds of the depth of the collars with a plastic filling

material, packing it well around the retaining posts. Select suitable cusp crowns for the molar and cuspid and place them in the ends of the bands to ascertain the occlusion. If too long, shorten the cusps or reduce the bands with engine corundum-wheels and when the correct articulation is found form a small square shoulder in the lingual edge of the cuspid and in the posterior grinding surface of the molar. Fill the remaining portion of the collars with plastic mixed somewhat thinner than the first lot, and set the cusp crowns in position. If there are antagonizing teeth, the mere closing of the patient's jaws will force the crowns to place. If there are no antagonizing teeth the crowns can be readily tapped to place with the mallet, using a piece of wood as a driver. Allow the filling material to set firmly, trim-

FIG. 472.



ming off any excess which may exude around the collars. Bridge supports or piers constructed on this plan are strong and durable, and likely to withstand any strain. Take an impression, and proceed to fit seamless collars to telescope over those already set upon the cuspid and second molar roots. It will be remembered that these collars are so made that each size telescopes into the next higher series. If the proper sizes are selected for the outside bands, the work of fitting is readily and quickly accomplished, forming tubes which slide easily over the supporting piers, and at the same time fit closely. It is only necessary to take care in shaping the tubes not to drive them too far up on the mandrels, and thus stretch them so as to destroy the fit. To the outer end of each of the tubes solder a small piece of gold plate, forming partial caps so placed as to rest when in position upon the shoulders previously cut in the cusp crowns. Adjust a truss bar of half-round gold wire, to the ends of which solder the tubes (Fig. 473). The truss is now

ready for the teeth, which may be of any of the forms used for this purpose, and they may be attached to the bar in any way desired. One of the strongest attachments is vulcanite.

"An easy modification of the plan just described is readily adapted to cases where only a small space is to be filled and one end of the bridge is to be supported by a sound tooth. Thus, suppose it is desired to bridge a space formerly occupied by the two inferior left bicuspids, the crown of the first molar being a mere shell. The operation would be essentially the same as in the previous case, except that the sound cuspid would be util-

FIG. 473.

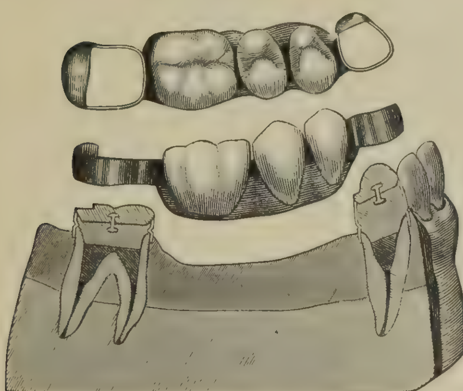
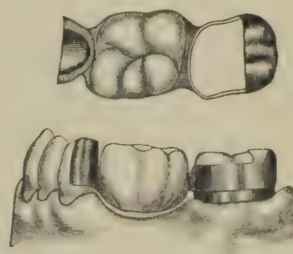


FIG. 474.



ized for one of the piers, as follows: Fit a seamless collar, cut out a portion of it so that it will embrace only about two-thirds of the cuspid crown, and solder a partial cap or cover to it (Fig. 474). Or, the cuspid crown may be separated from the lateral incisor with a diamond disk and the collar allowed to embrace the whole crown.

"The great desideratum in constructing a piece of bridge-work is, of course, the securing of perfect usefulness in mastication and speech, combined with absolute comfort and cleanliness. The closer a bridge approaches that condition where its wearer loses consciousness of its presence in his mouth, the nearer perfection it is. Scarcely less important, however, is the necessity of providing for repair. Accidents will occur, and the

system which superadds to usefulness, comfort, and beauty, ready facility for repairing breakages, is by so much superior to those which make no such provision. The place of a crown broken from a bridge constructed by any of the methods above described can be easily supplied, and the piece when repaired will be as strong and serviceable as it was originally."

METHODS OF CONSTRUCTING CROWNS AND BRIDGES IN CASE OF IRREGULARITY.

A young lady of about twenty-two years called upon the writer for services. Her mouth presented a very homely appearance, which was largely due to the ignorance or lack of judgment upon the part of her dentist in former years. The history of her case can be given in a few words. It is a characteristic of her family to have large, strong teeth, with the cuspids quite prominent; but in her mouth these teeth were so prominent as to disfigure her, and when she commenced to grow into womanhood, her mother took her to their dentist to have the irregularity corrected. This gentleman, as I have said, through bad judgment extracted the two lateral incisors, and allowed the cuspids to come down and forward to partially take their place. Then the mischief was done. The mouth was given a very coarse appearance by the large teeth being brought so near the center, and as they did not entirely fill the space, an ugly opening was left between these teeth and the central incisors. (See Fig. 475.) When the lady consulted me, it was with the idea of having the cuspids extracted, and two smaller teeth inserted upon either side; it was her wish at the same time to have it done, if possible, in some way so that she would not have to wear a plate. After studying her case it was, therefore, decided to extract those teeth which should have been removed in the first place,—the first bicuspids. Then with suitable regulating appliances the angle of the cuspids was corrected and they were drawn back so as to partially fill the space formerly occupied by the first bicuspids; at the same time the second bicuspids were brought into line, and all secured with retaining appliances, which were worn for several weeks. A lateral incisor was then prepared for either side, and inserted

by means of plate and pin bridges. Described by Professor Litch on page 302.

FIG. 475.

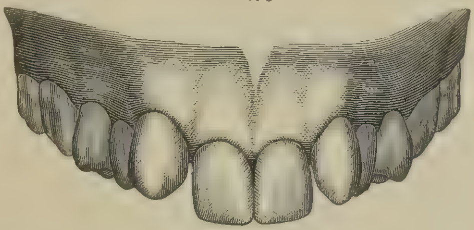
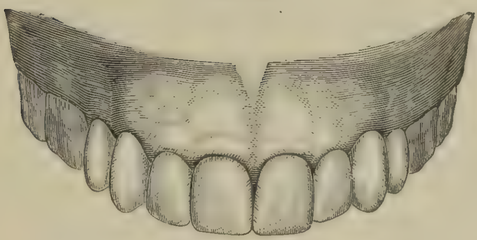


FIG. 476.



The result obtained was exceedingly gratifying, a fair idea of which is shown in Fig. 476.

Fig. 477 represents a case of irregularity treated by Dr. Bonwill, who says in his description of it—

FIG. 477.

"This shows a case of irregularity which was beyond correction, on account of the poor character of the teeth, their

position in the palatal arch, and the age of the patient. In such cases I do not hesitate to cut off the crown, destroy the pulp, and insert an artificial crown. The crown is brought in the circle and connected with the root by a strip of heavy gold plate. The plate is attached to the root with a post or a screw with a nut."

The next case was one treated by Dr. I. N. Broomell, who gives me the following description :—

"The superior cuspid was fully a quarter of an inch out of line; standing inside the arch to such a degree that a casual glance at the patient would lead one to suppose the tooth was missing. It was also imperfectly developed, so that, had age and other circumstances favored its restoration to the proper position in the arch, its malformation made it inadvisable to attempt such an operation. (Fig. 478.) The patient being desirous of having the deformity remedied, at least so far as appearances were concerned, I proceeded to do so in the following manner: Grinding off the irregular prominences of the tooth, I made it more perfectly conical in shape. After securing an impression of the deformed tooth and casting zinc dies, I swaged a hollow gold cap to accurately cover the whole surface and extend slightly under the gum. This added thickness of gold, when placed over the tooth, extended the labial surface to about what should have been the palatal line; thus permitting me to adjust by grinding and filing a porcelain tooth with its backing to the cap. These were soldered together and the appliance secured on the cuspid by oxyphosphate cement. In this case no pins were used, the cap alone being sufficient to hold the denture in position. (A, Fig. 478.) It has now been in the mouth some three or four years, during which time I have removed it several times in order to be satisfied that all was right under the cap. In fact, I consider that, when it is at all possible to do so, all appliances of this order, including small pieces of bridge-work, should be so constructed that they may be removed from time to time, thus affording an opportunity to detect any carious conditions.

"Another case which I will briefly present was somewhat

similar in construction to the one just described, but was inserted under different circumstances. For some reason unknown to the patient, he had lost from a lower incisor the entire labial surface, extending from the cutting edge to the gum-margin, and somewhat below it. The lingual half of the crown remained, and fortunately the pulp was not exposed. (Fig. 479.) With a corundum wheel I ground off the cutting edge of the tooth (to the horizontal dotted line seen in Fig. 479) until it was below the line of the pins in the porcelain tooth, which had been selected because its cross pins were near its cutting edge, and ground the porcelain tooth to fit the inclined surface of the natural organ. I then fitted a backing of very thin platinum, allowing it to extend over the whole back of the porcelain tooth, including the inclined surface. After making a cap to perfectly fit the lingual surface of the incisor, I pressed it around the sides until I could solder it to the backing, thus making a cap (A, Fig. 479) which completely covered the abraded tooth. Oxyphosphate cement being used in setting the denture.

A

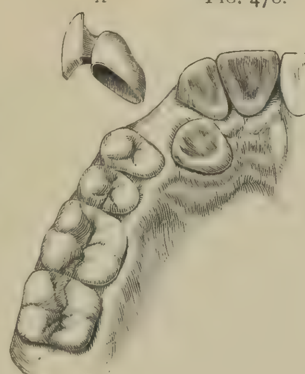


FIG. 478.

A

FIG. 479.

CHAPTER VI.

PARTIAL DENTURES RETAINED IN THE MOUTH BY MEANS OF CLASPS.

Remarks on the Use of Clasps.—Clasps or metallic bands have been long and very generally employed as a means of retaining parts of sets of teeth in the mouth, and are still used, to a limited extent, for that purpose by many practitioners. When these appliances are skilfully adjusted, and all the conditions pertaining to the mouth and remaining natural teeth are favorable to their application, they afford a certain, permanent, and satisfactory means of supporting partial dentures, and may be employed, under such circumstances, with comparative safety to the natural organs. When it is remembered, however, that in a lamentably large proportion of cases, clasps are carelessly or unskilfully formed and fitted to the teeth; that the organs of support are often indiscriminately selected, and are neither adapted in form, situation, or structure for such uses; and that they are frequently diseased and insecurely attached to the jaw, or are mutilated for the reception of clasps, we can readily understand to what unlimited extent this method is subject to abuses. In fact, few other special processes in mechanical practice have been so fruitful of evil as that under consideration, and the opprobrium which but too justly attaches to it in professional as well as popular estimation, is chargeable more properly to bad faith and *unskilfulness on the part of the operator, and to want of necessary attention to the cleanliness of the substitute and the organs of the mouth on the part of the patient*, than to any inherent unsuitableness of the method itself. Nevertheless, it must be admitted that, under the most favorable circumstances, the teeth clasped are not wholly exempt from liability to injury, and this circumstance in itself renders it the more imperative that the process should be surrounded by all the safeguards that skill and ingenuity can devise.

The opinion, at one time current, that the injury inflicted upon the teeth by clasps was mainly the result of mechanical action, has given place to the more defensible view that the causes concerned in its production are chiefly of chemical origin. Thus, the secretions of the mouth, with particles of alimentary and other substances, being retained between the clasp and the tooth for a sufficient period of time, and exposed to the favoring conditions of warmth and immobility, suffer a process of putrefactive decomposition by which acids are eliminated, and which, in their nascent state, act with perceptible energy upon the bone constituents of the tooth, producing disintegration and ultimate decay. The rapidity and extent of this action will depend much upon the nature and quantity of the acids present; the structural characteristics and vital resistance of the teeth; the mechanical execution, adaptation, and composition of the plate; and the personal habits of the patient with respect to cleanliness.

The most usual seat of structural disorganization in these cases is at the neck of the tooth, where the enamel is thinnest, and is sometimes limited to a circumscribed spot, but oftener extends on a line with the gum, involving nearly or quite all of that part of the neck of the tooth embraced by the clasp. At first the enamel becomes bleached and softened as though macerated, and is ordinarily very sensitive to both chemical and mechanical irritants. With a continuance of the cause, the superficial portions of the affected parts become more and more thoroughly disintegrated, and sooner or later assume the open form and characteristics of ordinary decay. If, as was formerly supposed, decay or solution of tooth-bone in these cases resulted from mechanical attrition, or wearing away of the enamel, the injury would be inflicted at points distant from the neck of the tooth where the clasp lies in more direct and immediate contact with the protuberant portions of the crown; but we find that decay, from this cause, is not only of infrequent occurrence at such points, but, on the contrary, the enamel here is frequently found condensed and polished by the mechanical action of the clasp. Certain conditions of the plate and clasp undoubtedly favor mechanical action and accelerate the destruction of the tooth; as where the clasp bears unequally with sharp and unfinished edges

upon the tooth, or where the base is faulty in its adaptation to the mouth, admitting, by its mobility, of irregular traction or pressure upon the organs of support. Whenever the artificial appliance is thus unskilfully constructed and applied, and free interspaces are furnished for the lodgment and retention of particles of food, and the teeth clasped are defective in structure, and we have conjoined with these an utter disregard of cleanliness in regard to the substitute and remaining natural teeth, the destruction of the latter is certain, rapid, and generally irretrievable.

The Teeth to which it is most Proper to Attach Clasps.—The utility, comfort, and appearance of a partial set of artificial teeth in the mouth will depend much upon the fitness of the natural organs selected for the purpose of support. "A clasp," says Professor Harris, "should never be applied to a loose tooth, or to one situated in a diseased socket, or which is so much affected by caries as to render its perfect restoration and permanent preservation impracticable, and when none but such can be had, the proper course to pursue is to extract every tooth in the jaw, and replace the loss of the whole with an entire denture. The application of clasps to diseased or loose teeth, always aggravates the morbid condition of the parts, and causes the substitute which they sustain to become a source of annoyance to the patient. Besides, such teeth can be retained in the mouth only for a short time, and when they give way, the artificial appliance becomes useless, and even while it is worn, it is not held firmly in place, but is moved up and down by the action of the lips and tongue, so that its presence can hardly escape observation from the most careful observer."*

Teeth, also, that are too short to admit of sufficient breadth to the clasp to impart stability to the substitute, and those that stand very irregularly in the arch, rendering it difficult for the patient to apply and remove the appliance, are unsuitable as organs of support.

In reference to the individual classes of teeth, it may be observed that the incisors, both as regards form and situation, are

* "Principles and Practice of Dental Surgery," page 717.

inadmissible for clasping, and are, therefore, never used for this purpose. The cuspidati, likewise, being placed conspicuously in the front part of the mouth, cannot be securely embraced without manifest exposure of the clasp; besides, the conical form of these teeth makes the use of a very slender clasp indispensable; hence, these teeth are rarely employed, and may only be used when, in the judgment of the operator, the necessities of the patient for the time being seem to require it.

Either the anterior or the second molars, when sound and firm, offer, in respect of their general conformation and position in the arch, the most desirable and efficient support for parts of sets of teeth. The crowns of these teeth generally afford ample breadth to the clasp; have nearly parallel walls; and furnish, by the strength and immobility of their attachments to the jaw, the greatest security to the artificial appliance. The anterior molars are preferable where these are remaining in good condition, or are susceptible of being properly restored and preserved if diseased or carious.

Of the bicuspids, the posterior are to be selected, if practicable, as these better favor the concealment of the clasps; to effect which more perfectly, in the use of either the first or second bicuspids, it will be sufficient in many cases to embrace only the posterior half of the crown.

The third molars, or wisdom teeth, will seldom admit of the application of clasps, as the crowns of these teeth are usually very short and cone-shaped, the walls converging abruptly from the gum; besides, the retractive forces applied to the anterior teeth of the substitute would, on account of the increased leverage consequent upon the extension of the plate back to these teeth, tend either to disengage the clasps or produce displacement of the teeth to which they are applied.

In Supplying the Loss of the Inferior Incisors, the appliance should, as a general thing, be attached either to the anterior or posterior bicuspids, as these teeth stand more nearly vertical in the arch. In fixing partial lower dentures, it will be sufficient to simply provide against mobility of the base, as they are favored rather than opposed, as above, by gravitation.

The Replacement of the Inferior Teeth posterior to one

or both bicuspids, however, is more frequently demanded; in which case it is customary to attach the clasps to the teeth immediately in front of and adjoining the vacuities on each side. It will not, however, be necessary to attach clasps in these cases whenever the edentulous portions of the jaw present a distinctly scooped form or marked concavity of outline, forming a kind of bed for the plate. If, on the other hand, the ridge falls back with a tolerably uniform inclination from the teeth in front, with no sufficient elevation at the base of the coronoid process, it may become necessary to provide against backward displacement of the substitute by attaching clasps, as before stated, to the teeth immediately in front. In any case, if the third molars remain, partial or stay clasps may be attached to each heel of the plate, and so adjusted as to rest against the anterior face of these teeth, obviating entirely the necessity of clasps in front.

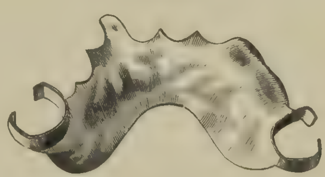
Separation of the Teeth for the Reception of Clasps.— The practice of separating the teeth with the file to provide for the application of clasps should always be avoided if practicable, since the liability of the teeth thus denuded of enamel to decay is greatly increased under circumstances so favorable to their disintegration. In the case of young subjects, especially, where the teeth are but imperfectly consolidated, and in adults whose teeth are defectively organized, presenting but a feeble resistance to the disintegrating agents usually present in the mouth, the use of the file, for the purpose indicated, is eminently pernicious, and should never be resorted to. When it is found necessary to separate the teeth for the reception of clasps, a thin diamond disk should be employed, as it is less annoying to the patient, does the work in less time, and is not so destructive to the tooth structure as the file.

Whenever a plain necessity for this operation exists, a careful examination of all the teeth to which it is proper to apply clasps should be made, and if decay is found upon their proximate surfaces, the separation should be made between the teeth so affected; and this circumstance should, in most cases, determine the selection, though the affected tooth or the one adjoining may not be esteemed, in other respects, the best

for the purposes of support. If decay exists on the proximate surface of only one of the teeth to be separated, a safe-sided diamond disk, revolved by the dental engine, should be employed, and the cutting confined entirely to the carious tooth, leaving the enamel of the one adjoining unbroken. The cavity of decay should be well filled, and the filed surface thoroughly condensed and polished.

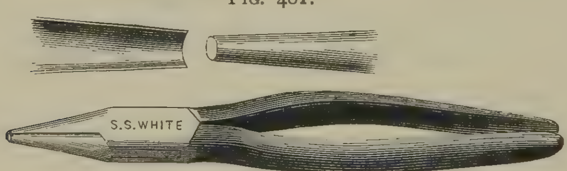
Modifications in the Form of Clasps.—1. *Plain Band.* The most usual form of clasp is that shown in Fig. 480. It consists of a plain metallic band of greater or less width and thickness, and is made to embrace the larger portion of the circumference of the tooth. In regard to the general properties of metallic clasps, it may be said that they should be, as nearly as practicable, of the same quality or fineness as the plate or base to which they are united; they should be heavy enough to impart adequate security to the attachment, say twice the thickness of the base, and exceeding this in some cases; and sufficiently elastic to embrace accurately the more contracted parts of the teeth after having been temporarily forced apart in passing over the enlarged portions of the crowns. In constructing a plain band or clasp, a strip of sheet lead or other pliable substance may first be fitted accurately to the plaster tooth, making it of the required width, and shaping the edge next the gum in conformity with the irregularities in the latter around the neck of the tooth; the exact counterpart of the pattern thus obtained is then cut from the plate to be used in the formation of the clasp. The strip thus obtained is then bent with round-nosed or grooved pliers (Fig. 481), until conformed as perfectly as possible to every portion of the surface of the tooth embraced by it. This coaptation should be sufficiently accurate to exclude perfectly all solid substances from between the clasp and the tooth. A more accurate adaptation of the clasp may be secured in the following manner: First secure a pattern, as

FIG. 480.



before described, and by this cut from a thin strip of platinum, say No. 30 or 32 of the gauge-plate, a band of the required size and form, and press or burnish it accurately to the form of the plaster tooth. The soft and pliant condition of this metal will admit of its being easily adapted to any irregularities upon the lateral walls of the tooth. The band thus molded to the tooth is then carefully removed from the model, or the mouth, if fitted to the tooth in the latter, and its central portion filled with a mixture of plaster and sand, with a small metallic wire or bar passing through the center to support it while soldering. The outer or exposed surface is then coated with a mixture of borax, and small scraps or fragments of gold plate of equal fineness with the main plate are placed at intervals and fused with the blowpipe until diffused uniformly over the surface.

FIG. 481.



Small pieces may be added from time to time, until the required thickness of the clasp is obtained. The piece should be heated uniformly throughout to induce an even flow of the gold over the exterior surface of the platinum ring. By this method a faultless adaptation of the clasp to the tooth may be secured, provided the form of the latter is correctly represented on the model. In all cases where the plain band is used, it should be made as broad as the tooth will admit of, as a clasp so formed gives greater stability to the plate, and does not endanger the tooth clasped in any greater degree than a narrow one.

2. **Standard Clasp.**—To guard more perfectly against the retention of vitiated secretions and particles of food around the neck of the tooth, a method of constructing clasps has been devised and introduced to the notice of the profession by Dr. C. W. Spalding, which, by leaving the cervical portion of the

tooth in a great degree uncovered, permits the action of the tongue and the natural circulation of the fluids of the mouth to wash or cleanse that portion of the tooth most liable to be injuriously affected. In commenting on this method, Dr. S. remarks: "The writer has for many years been in the habit of employing *narrow* clasps for the purposes of support, making them of sufficient thickness to give the required strength, and attaching them to the plate by means of standards, so arranged as to induce the removal of accumulations between the clasp and tooth, by the circulation of the saliva (Fig. 482). The use of one or more standards as a means of attachment also provides, by a variation of their length, for the grasping of the tooth at any desired point. If the tooth is long, and particularly if it is at the same time bell-crowned, the point selected should be toward the grinding surface, as far from the gum as is found practicable. If the tooth is short and of such form that it can be successfully clasped at no other point than that near the gum, the plate should be cut away at least one or one and a half lines from the tooth, and standards introduced for the purpose of promoting circulation, by affording a free passage for the ingress and egress of fluids. These standards should also be *narrow*, no wider than the clasp itself, and should constitute the only point of union between the clasp and plate. Half-round wire will be found to be a very convenient article for making clasps. The particular *form* of the clasp is, however, immaterial if it is both narrow and strong." *

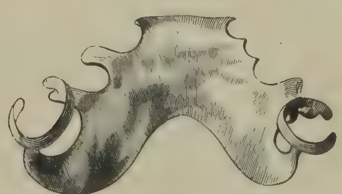
3. **Scalloped Clasp.**—Somewhat analogous in form to the clasp just described, and constructed with a similar design, is the one recommended by Dr. B. T. Whitney. A plain band of gold is fitted to the tooth in the manner first described, when that portion of it next the gum on the lingual side of the tooth is scalloped or cut away in the form of a semicircle or arch, the ends of the clasp being in like manner narrowed sufficiently to relieve them from contact with the neck of the tooth. The intermediate points of the clasp which serve to unite the latter to the base may be two or more in number, and should

* *American Dental Review*, vol. 1, p. 12.

be wide enough to impart adequate strength to the attachment. A clasp so formed and applied to the base will present very nearly the appearance of the standard clasp as represented in Fig. 482. Dr. W. recommends soldering but a single point at first, and then having tried the plate in the mouth and adjusted the clasp properly to the tooth, remove and solder the remaining point or points.

4. **Partial or Stay Clasp.**—This form of clasp, instead of embracing the tooth, is designed to steady or fix the substitute in place by simply resting against one side of the tooth to which it is applied. They should be so connected to the plate that, when pressed over the enlarged portions of the crowns of the teeth, they will spring readily into place and adapt them-

Fig. 482.

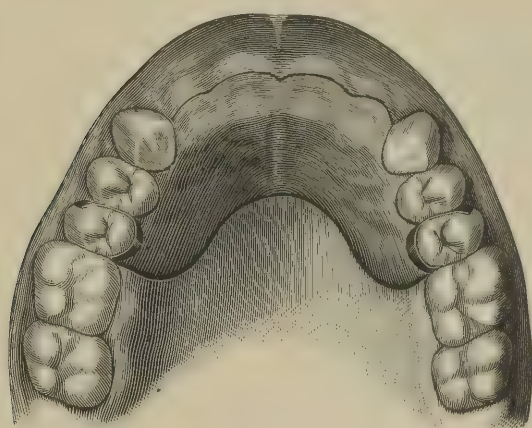


selves closely to the more contracted parts near the gum. In cases where there is no adequate opposing force to that exerted by the clasp, care should be taken that no more pressure is produced than is necessary to keep the substitute in place, as, without this precaution, outward displacement of the teeth is liable to occur, and the appliance, losing its bearing upon the teeth, soon becomes loosened and insecure in the mouth. The result alluded to should be particularly guarded against in the case of young subjects, whose teeth are easily moved by the application of very slight forces.

Modifications in the Form of Plates for Partial Dentures Supported in the Mouth by Clasps.—The particular form and dimensions of a plate when clasps are used will be mainly determined by the number and position of the teeth to be replaced, and by the location of the natural organs to which the clasps are attached. It will be sufficient in this place to indicate

the leading forms as they relate to the substitution of the several classes of teeth. In supplying the loss of a superior central or lateral incisor, it will be sufficient in many cases to attach the plate to either a bicuspid or molar on the same side. If two or more of the front teeth, however, are to be replaced, it is better to extend the plate on each side of the palatal arch, and attach to a bicuspid or molar (Fig. 483). In all cases where it is necessary to extend a narrow plate from the extreme front part of the mouth to a single tooth situated posteriorly in the arch, the former should be strengthened by soldering a narrow

Fig. 483.



rim of plate or half-round wire along the border next the teeth, and the clasp should, whenever practicable, pass in front of and embrace the anterior face of the tooth to which it is applied.

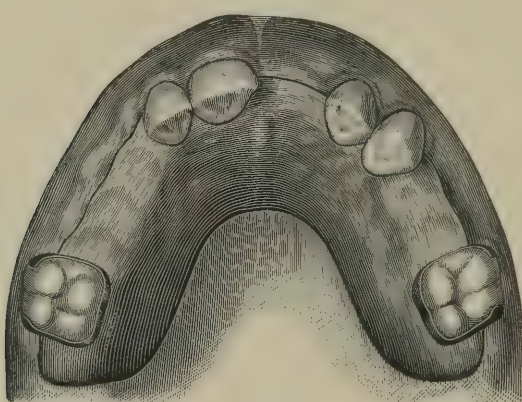
If an anterior bicuspid is to be replaced, the plate may be attached to the adjoining bicuspid, or if both are absent, then to the first molar, or the clasp may embrace both of the latter if remaining and no separation between them exists.

Take a case where it is necessary to supply the loss of the two bicuspids on one side, and the first bicuspid and first molar on the opposite, the plate being attached to an anterior molar and second bicuspid. The antero-posterior extension of the plate, in

connection with the bicuspid tooth, greatly favors the stability of the substitute, and, provided the plate and clasp are accurately fitted to the parts, the support afforded by a bicuspid tooth under such circumstances is equivalent to that furnished by a clasp about a firm and well-formed molar. A base so supported may be made to sustain a number of teeth with much security.

Either the anterior or posterior molars, if firm and securely attached to the jaw, will afford adequate support to a plate replacing all of the teeth anterior to them. Even a single molar situated on either side of the arch, if similarly circum-

Fig. 484.



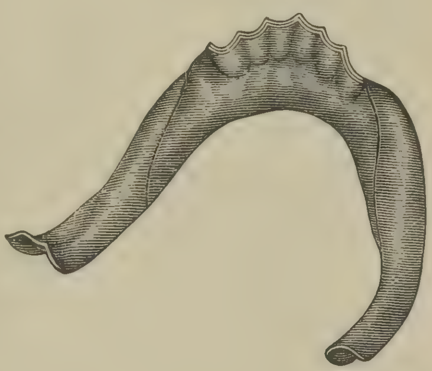
stanced, may be made to sustain, with tolerable firmness, a base supplying the loss of all the remaining teeth, though, ordinarily, *it is better to extract such teeth* and substitute an entire upper denture. In all cases, where any considerable number of teeth anterior to those clasped are to be replaced, and a vacuity on the ridge exists posterior to the latter, the plate should be extended back and overlap the ridge (Fig. 484), the latter affording a counter-point of resistance when traction is made upon the anterior teeth, thus directing the forces applied more on a line with the long axes of the teeth that sustain the appliance.

In Supplying the Loss of the Inferior Molars and Bicuspids, or any number of these teeth, the form of plate represented

in Fig. 485 is generally employed. The parts of the plate overlapping and resting upon the ridge behind are connected with each other by a narrow strip of plate extending round the ridge, hugging the lingual side of the anterior teeth. This latter portion of the plate should be accurately swaged to the form of the gum on which it rests, and should be made narrow enough to avoid encroaching upon the reflected portion of mucous membrane, the glands beneath the tongue, or the frenum linguæ.

Reinforcing.—To avoid wounding these parts, and to allow them unobstructed play, it will be necessary to make this portion of the plate quite narrow; and as a single thickness of plate would not impart adequate strength, *it is better practice to reinforce or double this connecting band*—the duplicate band extending back to the lateral wings of the plate, and crossing them obliquely, as indicated by the lines in Fig. 485. Additional strength will be given by doubling the entire plate, but this is not generally required. The outer border of those portions of the plate overlapping the ridge may be turned up to the depth of from half a line to a line, to form a groove or socket for the reception of the ends of gum teeth, or blocks, if such are used; while the inner margins should terminate in a rounded edge, extending from heel to heel of the plate, this form being given to it either by turning the edge over and filling in the groove with solder, or by soldering a narrow strip of plate or half-round wire along the border. The circumstances or conditions which make the use of clasps necessary in these cases, as well as those, also, which contraindicate their employment, have already been noticed. The practice of extending a narrow band or wire from the sides of the plate round the outer border of the ridge in front of the anterior

FIG. 485.



teeth, to prevent a backward displacement of the base, is liable to produce irritation and tenderness of the mucous membrane immediately over the roots of the anterior teeth, and should, therefore, never be resorted to unless there are no teeth remaining to which clasps may be applied.

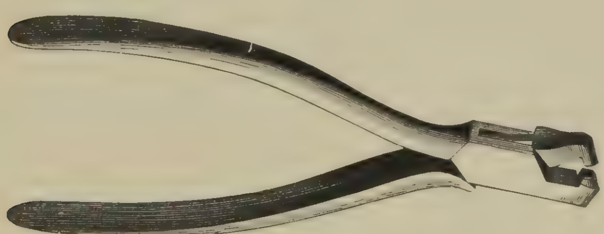
If the appliance is designed to restore the loss of teeth recently extracted, and where but little or no change has occurred from absorption of the parts, the portions of the plate which pass in between the adjoining teeth should terminate a line or more within the outer circle of the remaining teeth; and where the space, if it happens in the front part of the mouth, admits of two or more teeth, the edges of the extended portion of plate should be scalloped in correspondence with the festoons of the gum, as seen in Fig. 483. In such cases, plain or plate teeth, by which is meant those which represent only the crowns of the natural organs, should be employed; these, resting on the edge of the plate, will overlap somewhat, with their anterior edges resting directly upon the gum in front, taking the place occupied by the crowns of the extracted teeth. On the other hand, if sufficient time has elapsed after the extraction of the teeth to permit the changes in the form of the ridge to occur incident to partial or complete absorption of the parts, and a greater or less concavity exists between and above the teeth on the outside of the jaw, the plate, where it passes into the interspace, should extend some distance over the border of the ridge.

Swaging the Plate.—Having determined upon the proper form and dimensions of the plate for any given case, its outlines may first be traced upon the model; from this an exact pattern in lead may be obtained, or the pattern may be sufficiently ample to partially overlap the cut extremities of the teeth when the latter are not represented upon the die, having been previously cut from the model, as shown in Fig. 68. The outlines of the pattern are then traced upon the plate of gold or other metal used for the base. The redundant portions of plate are then cut away with plate shears and forceps, and the edges trimmed smooth with a file. A very convenient and almost indispensable instrument for cutting away the plate in conformity with the

palatal curvatures of the teeth, is the plate forceps as exhibited in Fig. 486.

The plate cut to the proper form is now placed upon the die and brought as nearly as possible into adaptation with a wooden or horn mallet; it is then placed between the die and counter, the latter resting on an anvil or other equally resisting surface, when the two metallic pieces are brought forcibly together with a few steady and well-directed blows of a heavy hammer. Tilting of the die, resulting sometimes unavoidably from a one-sided blow, may be obviated by placing a cone-shaped piece of cast-iron, brass, or zinc over the die, the base of the cone resting on the back of the die; by this expedient the force of the blow is

FIG. 486.



equalized and concentrated more directly over the die. The metallic swages should at first be brought cautiously together, and should be separated after the first blow or two, to enable the manipulator to detect and remedy any malposition of the plate before it becomes intractable from continued swaging. If, in the process of stamping, any portion of the plate is found cracking or parting, its further extension at that point may be prevented by flowing a little solder at the termination of the fissure.

Annealing the Plate.—During the progress of swaging the plate should be frequently annealed, which is done by bringing it to a full red heat under the blowpipe or by placing it in the furnace; the plate is thus rendered more pliant and can be more readily and perfectly forced into adaptation to the irregularities on the face of the die.

If, after somewhat protracted swaging, the plate is not conformed

perfectly to the face of the die, another and unused counter should be substituted for that in use; and, indeed, it is better in all cases to have duplicate copies both of the die and counter in reserve with which to complete the swaging, inasmuch as more or less deformity of both swages unavoidably occurs before the plate is brought into very accurate coaptation with the die. The stamping conducted thus far, the plate may be applied to the plaster model, and if found too full at any point, it should be trimmed with a file to the exact dimensions required. The margins of the plate adjoining the necks of the teeth should be permitted either to lie closely to them, or should be cut away, leaving a space equal to a line or more between the plate and the teeth; for if but a very narrow line of uncovered gum remains at these points, injury to the parts immediately surrounding the necks of the teeth is more liable to occur from strangulation of the interposed gum than if the plate were further removed from the teeth or rested directly against them.

Adjusting and Strengthening the Projections or Tongues of the Plate.—If the portion of the plate which passes in between the remaining teeth is quite narrow, as where but a single tooth is to be supplied, it should be strengthened by wiring the edges or doubling the plate at such point. It is also advisable in many cases, in order to provide more perfectly against fracture or distortion of the base in mastication, to wire or double the entire border of the plate adjoining the necks of the teeth. Narrow bands of gold resting against the necks of the teeth, constructed and adjusted after the manner of stay clasps, are sometimes soldered to the edge of the plate next the teeth; but unless the substitute is frequently cleansed, as well, also, as the teeth to which they are applied, serious injury is likely to be inflicted upon the teeth implicated.

The edges of those parts of the plate occupying the vacuities on the ridge should be filed thin to admit of a more accurate adaptation of the artificial with the natural gum, and should not, as before observed, ordinarily extend beyond the outer circle of the contiguous teeth, allowing the gum extremity of the artificial tooth to overlap and rest directly on the natural gum above. If, however, the concavity between and above the teeth on the

external border of the ridge is considerable, the interdentinal portions of plate should overlap the border completely and underlie the porcelain gum.

Adjusting Clasps to the Plate.—Having proceeded thus far in the operation, the plate and clasps should next be united to each other, and *the utility and comfort of the appliance in the mouth, as well as the safety of the natural organs used for the purpose of support, will depend in a great measure upon the accurateness of the relation of the several parts of the appliance to the organs of the mouth;* it being a matter of primary importance that the various parts of the substitute should be so adjusted to the remaining teeth—especially those to which the clasps are applied—and the ridge and palate, that it shall not, in any material degree, act as a retractor upon the organs of support, or furnish interspaces for the lodgment of food, while at the same time it should be so fitted as to be easily removed and applied by the patient.

Manner of Securing Clasps to the Plate.—The clasps having been fitted to the plaster teeth and the base swaged to the form of the palatal arch and ridge, the plate is placed in its proper position in the mouth and an impression in wax taken of the latter with the plate in place. The impression, with the plate adhering, is then removed from the mouth, its surface oiled, and a model obtained in the manner heretofore described. If, in separating the model and impression, the plate adheres to the latter, it should be detached and adjusted to the model and the clasps arranged upon the plaster teeth. The plate and clasps may now be attached to each other temporarily, with adhesive wax, in the relation they occupy on the model, and then removed carefully and the clasps and palatal face of the plate embedded in a mixture of nearly equal parts of plaster, sand, and asbestos. Before uniting the two pieces on the model with wax, however, the ends of the clasps should be slightly spread apart, in order that they may part readily from the plaster teeth, without, in any degree, changing their exact relation to the plate; in doing which, it should be observed that all parts of the clasps which are to be united to the plate should remain in close contact with the plaster teeth. After the plaster mixture, in

which the plate and clasps are embedded, has become sufficiently hard, the portions of wax which temporarily united the latter should be removed, and the surfaces of the clasps and plate, where they unite with each other, coated with borax ground in water to the consistency of cream; small pieces of solder are then placed along the lines of contact, the investment heated in the furnace until the plate acquires a full red heat, when it is removed, placed upon a suitable holder, and the solder fused with the blowpipe.

Whenever the form and inclination of the teeth to be clasped are not fairly represented on the model, owing to dragging or displacement of the wax in withdrawing the impression, the difficulties of securing a proper relative adjustment of the several parts of the appliance will be increased; but either of the following methods, if carefully and accurately manipulated, will secure accurate results:—

1. Plaster-of-Paris or modeling compound may be substituted for wax when taking an impression with the plate in the mouth. With the proper use of these materials, the exact form and inclination of the teeth will be better preserved; and when employed they should be filled in with plaster for the model immediately after removing them from the mouth. The subsequent steps in the operation are precisely similar to those described when wax is used.

2. Another method is to adjust the clasps and plate to the parts in the mouth, attach them temporarily in their proper relation, and remove, invest, and solder in the usual way. This may be accomplished in the following manner: First, spread apart the ends of the clasp somewhat to permit it to be easily removed from the tooth; place this upon the tooth in the mouth to be clasped; then adjust the plate, and attach the two to each other by pressing a piece of stiff, adhesive wax in against the clasp and plate where they unite; harden the wax by placing against it, for a few minutes, the end of a napkin moist with cold water; then remove the plate and clasp carefully from the mouth, and invest and solder as before. The plate, with one clasp permanently attached, is now placed back in the mouth, and the second clasp adjusted to the tooth on the oppo-

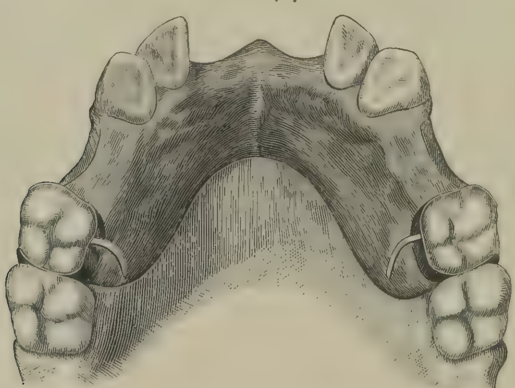
site side in the manner before alluded to; this is then temporarily fastened to the plate and otherwise treated in like manner as the one first described. If the teeth to be clasped are favorably formed and regularly arranged in the arch, both clasps may, at the same time, be temporarily attached to the plate in the first instance; if not, it will be impracticable to remove them from the teeth without disturbing the wax and changing their relation to the base and the teeth clasped. The additional labor and consumption of time incident to a separate attachment of the clasps will, in proportion as they secure better results, amply reward the operator for his painstaking.

Plaster is sometimes substituted for wax in this process; in which case it is introduced into the mouth on a small piece of wax or sheet lead and pressed gently against the uniting portions of the plate and clasp, and allowed to remain until sufficiently hard. Any superfluous portions around the tooth that may hinder the easy removal of the clasp should now be cut away, when the pieces so attached to each other are removed from the mouth. A separation of the plaster from the clasp or plate, or both, may occur when removing the latter; in this case the several parts may be readily and accurately adjusted to each other again in their exact relation when out of the mouth, as the latter will be plainly indicated by the impression made by the plate and clasp in the plaster. Being readjusted, they may be further secured by sticking them together with a little softened wax, when they are invested, the temporary fastening of plaster removed, and the pieces united by soldering. The use of plaster in these cases is due to Dr. Lester Noble, and unquestionably possesses many advantages over wax for the purpose, as the latter is liable, even with the most skilful manipulation, to become displaced in removing it from the mouth; and this change, when it occurs, not being indicated by inspection of the wax, is incapable of timely correction.

3. Still another method is that contrived by Dr. Fogle and described by Dr. Cushman in the tenth volume of the *American Journal of Dental Science*. It consists in securing the proper relation of the clasps to the teeth in the mouth by the use, in the first instance, of what are termed "temporary fastenings."

The plate and clasps are first applied to the model, and are then connected by a narrow strip of plate or piece of wire bent in the form of a bow, the concavity facing the model, one end of which is soldered to the palatal side of the clasp, and the other to a contiguous point upon the plate, as exhibited in Fig. 487, and the pieces thus temporarily united are removed from the model and adjusted to the parts in the mouth. If the position of the clasps is found in any respect faulty, they can be easily and accurately adapted to the walls of the teeth by bending or twisting the connecting strip in any desired direction with pliers or other instruments suitable for the purpose. This accom-

FIG. 487.



plished, the plate and clasps are removed, and the operation of permanently uniting the clasps to the plate performed in the usual manner.

In the use of partial dentures, there is always increased liability to injury of the soft parts by reason of pressure being concentrated upon limited or circumscribed portions of the alveolar ridge embraced in interdental spaces, thereby diminishing resistance to the pressure of the plate at such points. As a consequence, the latter is forced into the soft tissues, producing more or less irritation and inflammation, and consequent tenderness and pain on pressure, and, generally, either partial denudation of the necks of the natural teeth abutting upon the interdental

spaces, or strangulation, congestion, and hypertrophy of the gum in immediate contact with them.

A simple device, by which the results alluded to may be obviated, consists in attaching to the clasps, above or below, a strip or spur of gold at suitable points, long enough to overlap or rest upon the masticating surface of the tooth clasped, forming a hook or partial crown cap. These will afford fixed points of resistance to pressure and effectually prevent the plate impinging upon the underlying tissues. The same expedient may be adopted also, in the case of partial dentures retained by adhesion or atmospheric pressure, by attaching similar gold spurs or caps to the border of the plate at suitable points contiguous to the bicuspids and molars.

FIG. 488.

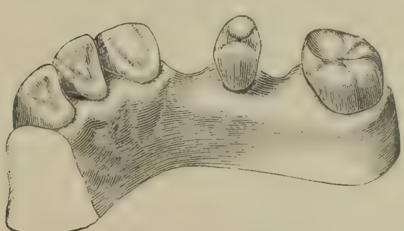


FIG. 489.

Charles Rathbun, of London, England, relates, in the *Dental Cosmos* of December, 1886, a method of constructing partial pieces which embodies the same principle of crown-support as described above, the essential details of which are here given :—

" In Fig. 488 we have the first bicuspid standing ; the second bicuspid and cuspid in that case filling the rôle of the lateral, missing from its position. The bicuspid is pear-shaped, its largest diameter being just below the grinding surface, and the molar is a trifle under-cut. A No. 7 or 8 English gauge gold plate, struck from a model made from a modeling compound impression, would not touch the necks of either the bicuspid or molar, owing to the fact that these teeth would ' draw ' a little in the impression, and it should be fitted over the shoulder at the neck on the lingual side of the cuspid, left clear of it at the distal side, and have a stay or clip resting just above the prominence on

that side of the tooth. A band should be soldered to the plate at the lingual side of the bicuspid, to grasp that tooth at its largest point, viz., about one-third of the distance from the grinding surface to the neck ; also, a band fitted to the molar to reach from about the middle of the lingual side far enough around the mesial face to clasp over the prominence at the mesio-buccal aspect of the tooth ; this band to be fitted to grasp the tooth at its fullest part, as in the case of the bicuspid. (See Fig. 489.) Wires or clasps at the necks of teeth of this class do no end of damage to the teeth, and are open to the great objection that a case may go in very hard, and yet when the clasps are past the large part of the teeth the case is quite loose and shaky. The bands I have described do not bear on the teeth at all until the case is within about a line of its place, and then each one bears on its own tooth irrespective of the others, and, be it borne in mind, touches the tooth at a point where the chance of decay is simply infinitesimal. If a porcelain cuspid and bicuspid be ground in properly, the clasps will not be visible externally, which cannot be said of the broad gold band carried across the buccal face of the natural tooth."

CHAPTER VII.

PARTIAL DENTURES SUPPORTED BY ATMOSPHERIC PRESSURE OR ADHESION.

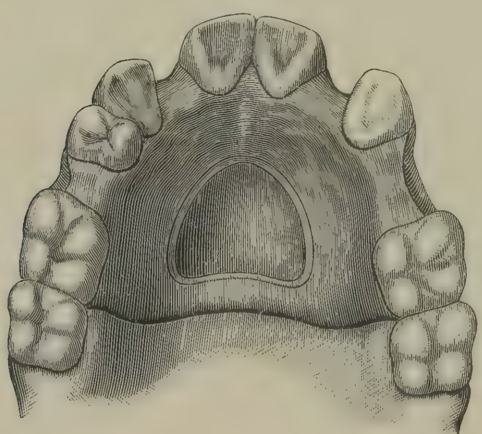
The method of attaching partial sets of teeth to the superior jaw by means of atmospheric pressure, or by adhesion, is much more generally practised than formerly, and whenever the condition of the soft parts of the mouth, the general configuration of the palatal arch, and the antagonism or occlusion of the artificial with the natural teeth favor its adoption, there are good and sufficient reasons why either of these forces should, in all practicable cases, be utilized in preference to the use of clasps for purposes of attachment.

Modifications in the Form of the Base.—If vacuities exist at various points on the ridge, the plate on which the teeth of replacement are mounted should be ample in its dimensions, covering nearly or quite all of the hard palate. The general form of the base, where several teeth scattered throughout the arch are required, is shown in Fig. 490. In most cases, whether but one or a greater number of teeth are to be replaced, increased adherence and stability of the substitute will be better secured by permitting the plate to cover the larger portion of the roof of the mouth; though, in cases that present the best form of the vault, a diminished surface may be given to the base with equally satisfactory results. In the substitution of a single incisor, for example, it will frequently be sufficient to employ a very small plate covering only a part of the anterior sloping wall of the palate. In the latter case the plate used may be very thin, say No. 30 standard gauge; it will thus impede the movements of the tongue less, and may be swaged more accurately to the parts. If constructed with an air-chamber, the latter should be quite shallow.

A somewhat anomalous form of atmospheric-pressure plate employed in the substitution of one or two bicuspid teeth on

each side is described by Professor Taft,* the design of which is to secure in such cases increased stability of the substitute, while much of the palatal arch is left uncovered. It consists, of two lateral cavity plates accurately adjusted to the sloping walls of the palate on each side, immediately adjoining and partly occupying the spaces to be supplied. These lateral plates may be made as large as a dime, or somewhat larger, and of an elliptical shape if both bicuspids on the same side are to be replaced, and are connected with each other by a narrow band of gold plate, two lines or more in width, having an anterior curvature, and resting on the

FIG. 490.



front wall of the palate, two or three lines behind the anterior teeth. The entire appliance may be constructed from a single piece of gold plate swaged accurately to the parts; or the lateral plates and connecting band may be separately swaged and secured in their proper relation to each other in the mouth with wax or plaster, when they are carefully removed, invested, and soldered together; it should then be reswaged to correct any change of relation that may have happened during the concluding manipulations. The liability of the plate to ride upon the central and raised portion of the palate, when pressure is made upon one

* *Dental Register of the West*, vol. XIII, p. 112.

side, throwing the plate off from the ridge on the other, as in the case of a base extending across the arch, is in a great degree obviated by the method just described.

Manner of Forming an Air Chamber.—Atmospheric-pressure plates for partial cases are constructed with a central air chamber; in which case, the part of the model representing the chamber may be formed in either of the ways mentioned in the chapter on "Plaster Models." The model prepared, the form of the plate to be used is first indicated thereon, and from this a pattern in sheet lead is obtained, which is placed on the plate of gold or other metal, and its outlines traced with a pointed instrument; the redundant portions are then cut away with plate shears and forceps. The plate is now placed on the die and brought as nearly as possible into adaptation to the latter with the mallet and pliers; it is then interposed between the die and the counter, and swaged until it conforms perfectly to the face of the former, annealing the plate frequently to render it more pliant and manageable under the hammer.

The Use of a Tracer in the Swaging Process.—Unless the plate used is purer and thinner than is generally employed, or than is consistent with the required strength, it will fail to be forced perfectly into the groove around the chamber by the process of swaging alone; a more definite border, however, may be formed by forcing the plate in at this place with a small, smooth-faced stamp or tracer, shaped to the angle of the groove, passing round the chamber and carefully forcing the plate in with the stamp and a small hammer or mallet until a somewhat sharp and abrupt angle is obtained to the palatal edge of the chamber. After the chamber is as perfectly formed as possible in this way, the plate should be well annealed and again swaged to correct any partial deformity occasioned by stamping the chamber.

The Soldered Air Chamber.—A still more perfectly defined angle may be given to the borders of the chamber in the following manner: After swaging the plate sufficiently to indicate the exact position and form of the chamber, the portion forming the latter should be separated from the main plate by completely dividing it with a saw, or small, sharp, chisel-shaped instrument, cutting on a line with the groove around the chamber until the

latter is entirely separated. The cut portion of the main plate is then trimmed evenly with a file, being careful not to enlarge the opening more than is required to remove the irregularities of the edge formed in cutting. The plate, with its central portion removed, is then placed upon the die, when a separate piece of gold cut to the general form of a chamber, but somewhat larger than the opening in the main plate, is adjusted over the chamber, and struck up with the plate until the overlapping portions of the central piece are forced down upon the plate around the margins of the chamber. It is not, however, always necessary to employ a separate piece of gold for the chamber, as the central portion cut from the plate in the first instance may be sufficiently enlarged for the purpose. This is accomplished by first flattening out the detached portion, annealing it, and then passing successive portions of its edges a sixteenth of an inch or more between the rollers, the latter being sufficiently approximated to produce a perceptible thinning of the margins. When the entire border of the chamber piece has been thus attenuated and extended, it will be found so much enlarged that, when adjusted to the die and swaged in connection with the main plate, its borders will overlap and rest upon the margins of the opening in the base, as in the other case.

The portions of the plate and cut chamber lying in contact are now coated with borax and pieces of solder placed along the line of union on the lingual side of the plate, when the two pieces, being transferred to a bed of charcoal, are permanently united by flowing the solder with a blowpipe. Sufficient heat should be applied to induce an extension of the solder between the two portions of plate, filling up completely the gap between them to the edge of the orifice in the main plate, forming, at this point, a square and well-defined angle to the margins of the chamber.

CHAPTER VIII.

METHOD OF OBTAINING AN ANTAGONIZING MODEL FOR PARTIAL DENTURES; SELECTING, ARRANGING AND ANTAGONIZING THE TEETH; INVESTING, ADJUSTING STAYS, SOLDERING, ETC.

Having constructed the plate or base to be used as a support for partial sets of teeth in either of the ways described in the preceding chapter, it will be necessary, before arranging the teeth on the plate, to secure an accurate representation of all the remaining natural teeth of both jaws in plaster, preserving accurately the relation which these organs bear to each other in the mouth. This is effected by what is called an *antagonizing model*, and may be secured in the following manner:—

Taking the "Bite."—A roll or strip of adhesive wax is first attached to the lingual border of the plate, and its adhesion secured by holding the opposite side of the plate for a moment over the flame of a spirit lamp. The wax used for articulating purposes should be harder and more tenacious than plain beeswax, and may be compounded from the following formula:—

Beeswax,	1 pound.
Gum mastich,	2 ounces.
Spanish whiting,	1 ounce.

The wax is first melted in a shallow vessel, and the mastich, finely pulverized, gradually added, and then the whiting, stirring constantly until thoroughly incorporated. The rim of wax being arranged on the plate, all superfluous portions overhanging the margins occupied by the remaining teeth are cut away; the plate may then be placed on the model and the wax again trimmed, leaving it somewhat fuller than the outer circle of the teeth, and from one to three lines longer than those immediately adjoining the spaces. The plate, with the wax attached, is then placed in its proper position in the mouth, and the patient instructed to close the jaws naturally until the remaining teeth

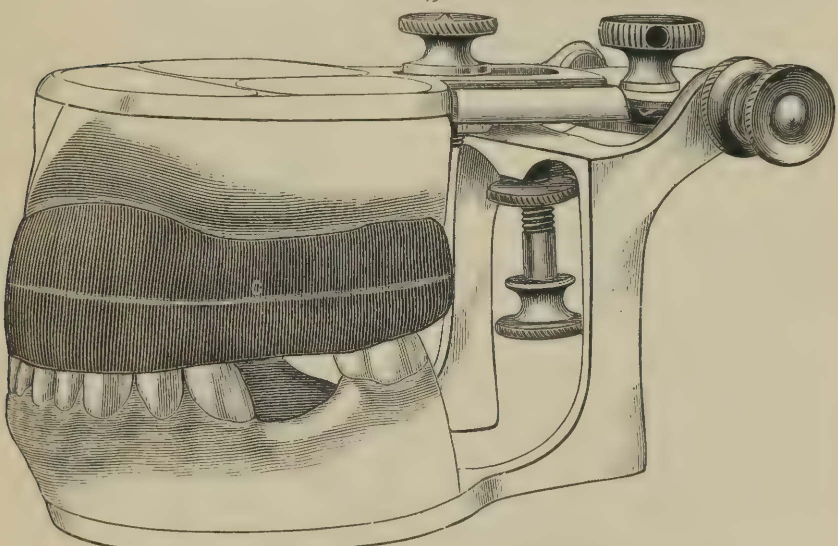
meet; one-third or more of the crowns of the opposing teeth opposite the spaces will thus be imbedded in the wax. A still fuller impression of the opposing teeth may be obtained, if desired, by pressing the edges of the wax down upon the crowns with the finger.

The Mesial Line.—If a series of anterior teeth are to be replaced, the mesial line of the mouth in front should be indicated upon the wax by drawing a line vertically across the latter to serve as a guide in the arrangement of the central incisors and adjoining teeth. The plate and wax are then carefully removed from the mouth and again placed upon the plaster model, the latter having been previously obtained from an impression of the parts with the plate in the mouth.

Securing the Antagonizing Models.—The method of securing the antagonizing models as practised by many is to place the model on a slip of paper with the plate and wax upward, and the heel of the model extended from one to two inches posteriorly to form an articulating surface for the remaining portion of the antagonizing model. The added portion of plaster may be confined by a narrow strip of wax or sheet-lead extending back upon each side of the model, into which a batter of plaster is poured to the depth of half or three-fourths of an inch. When hard, the edges and upper surface of the added plaster should be trimmed smooth, and a crucial groove, or two or three conical-shaped holes, cut in the surface of the latter to secure a fixed and definite relation of the two parts of the model. The articulating surface is then varnished and oiled to prevent the next portion of plaster from adhering; the imprints of the teeth in the wax are also oiled. The open space looking into the palatal vault should be closed with a sheet of softened wax to prevent the next portion of plaster from flowing into the cavity underneath. A batter of plaster is now poured carefully upon the exposed surface of the wax, filling the imprints of the teeth perfectly, and extending back upon the heel of the model until it acquires a depth of half an inch or more. When sufficiently hard, the two sections of the model are separated, superfluous portions trimmed away, and the entire surface of both pieces glazed with varnish, and if the manipulations have been

accurate, this simple contrivance will exhibit all the parts represented in plaster in precisely the same relative position which they occupy in the mouth. The writer feels, however, that a more elegant and accurate method of securing the antagonizing model, is to take a full impression of the antagonizing teeth in wax or modeling compound. Secure a plaster cast from same and adjust the two models properly upon an articulator, as shown in Fig. 491.

FIG. 491.



Selecting, Arranging, and Antagonizing the Teeth.—The teeth of replacement should harmonize, as nearly as possible, in size, configuration, and color, with those remaining in the mouth; and when selecting teeth for any given case, the operator should be provided with a sufficient number of sample teeth to meet every requirement, by comparison, in respect of the various tints or delicate shades of color characteristic of the natural teeth and gums. The required size and form of the artificial teeth may be determined with tolerable accuracy by a comparison with those on the plaster model, but the form or figure more certainly by a careful inspection of those in the mouth.

Although there are almost limitless varieties of manufactured teeth, both as respect form and color, it is not always possible, in partial cases, to obtain such as will harmonize with the natural teeth. As to form, a much closer resemblance to the natural organs in immediate relation with those of replacement can be obtained by cutting away more or less freely from the cutting edges of the incisors, and the cusps of bicuspids and molars, in cases where the natural teeth are much worn. The ground surfaces may afterward be polished with pumice on a buff, and finished with rotten-stone and oil. The exigencies of practice, in respect of partial sets, will often require the re-shaping of ready-made teeth by grinding, and the original form should never be preserved at the sacrifice of utility and appearance.

To Secure Harmony of Color in the use of manufactured teeth as found in dental depots is not always practicable. There are often conditions of the natural organs associated with decay and organic discolorations which it is impossible to match with porcelain teeth provided by manufacturers for general purposes. Such needs of the practitioner can only be adequately met by selecting the teeth and having them stained before baking at the dental depot.

Grinding the Teeth.—A greater or less change in the form of porcelain teeth will be required, in nearly all cases, in fitting them to the vacuities in the jaw ; and this is more particularly so in those cases requiring the use of gum teeth. This alteration of form is effected by grinding away portions of the tooth upon an emery or carborundum-wheel attached to the dental lathe. (Fig. 492.) If the edentulous portions of the ridge have suffered but little change of form by absorption, as where the teeth have been recently extracted, and plain teeth (those representing only the crowns of the natural organs) are used, the posterior portions of the base of the latter resting upon the margins of the plate will only require to be conformed to the irregularities on the surface of the base-plate, grinding sufficiently to give them the proper length and relative position, while their anterior cervical portion is permitted to overlap the edge of the plate and *rest directly upon the gum in front* on a line

with the adjoining teeth. When, however, a considerable concavity exists in the ridge and external border, and single gum teeth are employed to restore the customary fulness and contour of the parts, the gum portion of the tooth should be ground away on its posterior face sufficiently to restore the

FIG. 492.

circle of the gum on the external border of the alveolus, and from the base of the tooth where it rests upon the plate, to admit of a proper relative position of the artificial crown; while those portions of the porcelain gum terminating at and adjoining the remaining teeth, next the spaces, should be formed with

a thin, retreating edge, where it laps upon the natural gum, giving to the parts, when the substitute is adjusted to the mouth, the appearance of an unbroken denture and a continuous gum. When the space to be supplied requires a series of two or more single gum teeth, the latter should be united to each other with the greatest care and exactness by grinding the proximate edges of the gum portions until the coaptation is such as to render the seams imperceptible in the mouth. In adjusting the porcelain teeth to the plate, the base of each tooth should be ground to rest as directly and uniformly on the plate as possible; for if thrown, in any degree, from the plate, the whole strain in mastication will come upon the platinum rivets, and, in a comparatively short time, the latter will either be entirely worn or cut off, or the artificial crown will be fractured on a line with the pins.

Antagonizing Partial Dentures.—In antagonizing partial sets of teeth, the indications pointed out by the customary closure of the natural organs should be followed as nearly as the form and position of the opposing teeth will permit. A changed or abnormal relation of the teeth of both jaws, however, frequently renders it difficult to effect a satisfactory adjustment of the teeth of replacement. If, in the case of the bicuspids, for example, one or more teeth in the under jaw project into a vacuity above to the extent of one-third or more of its depth, a direct closure of the substituted organs upon these, in the ordinary manner, would be impracticable without a corresponding shortening of the porcelain teeth, enforcing, in such cases, an inharmonious arrangement, entirely inconsistent with the just requirements of the case. The difficulty cited, or any of the various modifications of it, may be overcome wholly, or in part, in one of two or three ways. If the teeth encroaching upon the opposite space are very loose, as is frequently the case with those that have become elongated from the long-continued want of an adequate opposing force, or are hopelessly carious or otherwise diseased, they should be at once removed. If they remain firm and sound, and stand slightly within the circle of the teeth of the opposite jaw, or if they have somewhat of an inward inclination in the arch, the vacuity opposite may be filled with

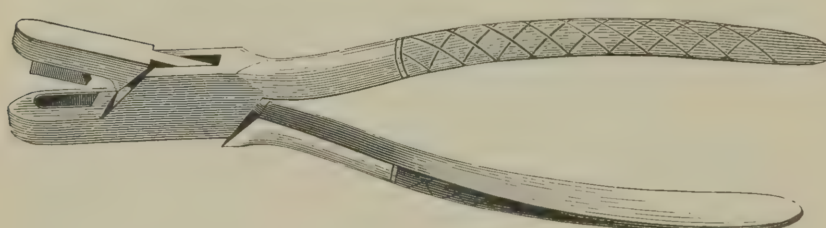
non-masticating teeth, as a canine, on the lingual side of which an antagonizing cusp of gold may be constructed, allowing the point of the cuspid to lap over the labial face of the encroaching tooth or teeth ; or a bicuspid, manufactured for the purpose, with the inner cusp near the base of the tooth, may be used instead. Additional room may be provided in such cases for the overlapping portion by grinding away from a corresponding point on the opposing tooth. If, however, taking the most impracticable case, the intruding teeth are sound and firm, and stand vertically in the arch, closing between the opposing teeth on a line with, or somewhat outside of, the outer circle of the latter (the elongation of such teeth being rather relative than absolute, as where it results from a mechanical wearing away of the remaining antagonizing teeth and a corresponding approximation of the jaws), the practitioner will be compelled either to submit to a malarrangement of the teeth of replacement by grinding away sufficiently from their grinding surfaces to permit an unobstructed closure of the natural organs, or if the remaining teeth are few and poor in structure, extract them, and insert a full denture.

In view of the difficulties which so frequently present themselves in connection with the arrangement of artificial teeth in partial cases, it may not be amiss to observe that, however essential to the natural and agreeable expression of the individual an exact and harmonious arrangement of the teeth of replacement may be, this requirement should, in some degree, be disregarded whenever the necessities of the patient, in respect of the comfort and utility of the appliance or the safety of the natural organs, demand it ;—to what extent appearances should be sacrificed to these considerations will depend upon the peculiar exigencies of the case, and cannot, therefore, be specifically stated. On the other hand, it may be observed that, if a sufficient number of the natural teeth are remaining in both jaws to enable the patient to perform, with tolerable efficiency, the act of mastication, the mere utility of the substitute in regard to the performance of this function may be partly or wholly disregarded whenever there is sufficient reason to apprehend that the substituted organs cannot be antagonized with a view to the comminution of food without endangering the permanency and usefulness

of the appliance by necessitating the application of forces unfavorably directed.

Investing.—Having arranged and antagonized the teeth as accurately as possible on the plaster model, the piece should be placed in the mouth to detect and remedy any faultiness that may be found to exist either in the adaptation, position, or antagonism of the artificial teeth. It is then removed and embedded in a mixture of plaster, sand, and asbestos, in the proportion of about two parts of the former and one part each of the latter. The body of the investment may be surrounded by a copper or sheet-iron band to prevent it from breaking away whilst adjusting the stays or linings to the teeth. All

Fig. 493.

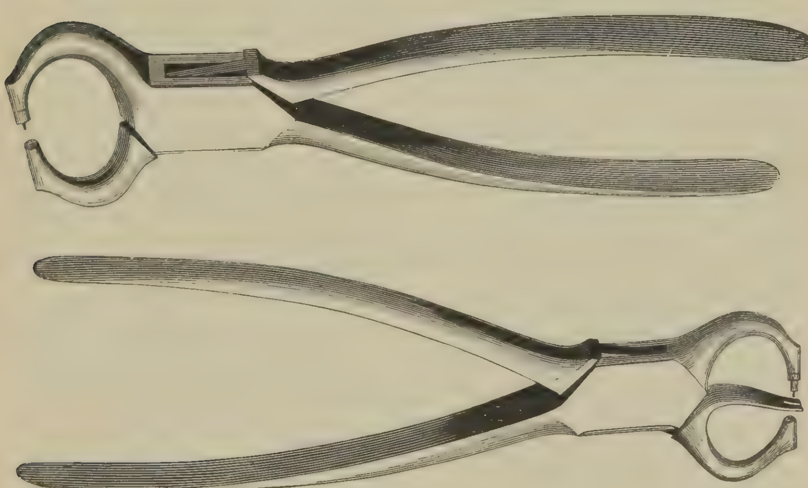


parts of the plate and teeth, except the lingual side of the former and the backs of the latter, should be encased to the depth of half an inch or more, and when the latter is sufficiently hard all traces of wax from the inside should be carefully detached with suitable instruments.

Manner of Backing the Teeth.—The piece is now ready for the adjustment of stays or backings, which, when permanently united by soldering to the base and teeth, are designed to sustain the latter in position. These supports are formed from plate somewhat thicker than that used for the base, a heavier and stronger stay being necessary when they are not united laterally, as when plate teeth are used. If, however, single gum or block teeth are employed, and the stays are joined, forming a continuous band, plate one-half thicker than that used for the base will,

ordinarily, impart adequate security to the attachment. A plain strip, corresponding in width with the tooth to be lined, is cut, and the end resting on the main plate conformed accurately with the file to the irregularities on the surface of the latter, and in such a manner as to permit the strip to take the direction of the tooth. The general form of the stay may, in the first place, be obtained by cutting a strip from a piece of gold with a pair of plate forceps (Fig. 493). The points upon the stay to be pierced

FIG. 494.



for the admission of the platinum pins may be ascertained by coating the surface of the former with wax softened in the flame of a spirit-lamp, and pressing it first against the lower pin, the point of which will be indicated by an indentation of the wax. The backing is then perforated at this point with a plate punch, two forms of which are exhibited in Fig. 494, one armed with a tongue, which, when the plate is pierced, forces the latter from the punch. The strip is then reapplied to the upper pin, and the second hole obtained in like manner as the first. Instead of using wax, the ends of the rivets may be stained with some pigment, which will show the points to be pierced in the lining.

The stay should be adapted accurately to the face of the tooth; it is then cut to the proper length, reaching nearly or quite to the point of the tooth, and shaped with a file to the general form of the crown. When the stays are to be united they should be formed with a shoulder at a point corresponding with the neck of the tooth, and the proximate edges below united closely by square edges, or the latter may be beveled and made to lap upon each other. The process of soldering will be greatly facilitated and the piece will be more easily and artistically finished by securing, in the first instance, a perfect coaptation of all the parts which are ultimately to be united. The sides of the holes in the stays facing the plate should now be enlarged or countersunk with a spear-shaped or conical bur drill, and when applied to the teeth the projecting ends of the platinum pins are cut off even with the backings and then split and spread apart with a small chisel-shaped instrument; a head will thus be formed to the rivets when solder is fused upon them, which will prevent them from drawing from the linings.

The Soldering Process.—All the lines of union between the several pieces should next be well scraped, exposing a clean, bright, metallic surface to the solder; the seams are then coated with borax, ground, or rubbed in clean, soft water to about the consistency of cream;* after which small pieces of solder are placed along the joints and over the points of the platinum pins. The piece thus prepared is now placed in the furnace or ordinary fireplace in order to heat the entire mass preparatory to soldering. The fuel most proper for this purpose is charcoal, either alone or combined with coke, the latter being preferable for the reason that charcoal alone is more quickly consumed, and burning away more rapidly underneath the piece is liable to drop to the bottom of the furnace. The fuel should be broken into small pieces and built up around the borders of the investient in order that all parts of the latter may be uniformly heated. The heating process should be conducted gradually, for if the piece

* Slate is often used for this purpose, but is unfit, as, in rubbing the borax, loosened particles of the former become mixed with the latter and impede the flow of the solder, and becoming entangled render it unclean and porous. Ground glass or a porcelain slab is the best for the purpose.

to be soldered is subjected suddenly to a high heat, the plaster will be displaced by the too rapid evolution of vapor, and the integrity of the porcelain teeth will be endangered. The piece may be allowed to remain in the fire until the plate acquires a visible red heat, when it should be removed, placed on a suitable holder, and the solder fused with the blowpipe. A broad, spreading flame should first be thrown over the entire surface of the plate and border of the plaster until the temperature of the entire mass is nearly that required to fuse the solder, and which is indicated by the latter settling and contracting upon itself; the flame may then be concentrated upon a particular point, as at the heel of the plate on one side, passing round from tooth to tooth until all the parts are completely united and the solder is well and uniformly diffused.

Having united the teeth to the plate, the piece may be allowed to cool gradually, or it may be plunged after the lapse of a few minutes into boiling water without risk of injury to the teeth. When cool, the plaster is removed and the plate placed in the *acid bath* (a solution of equal parts of sulphuric acid and water), where it may be allowed to remain until the discoloration of the plate and the remains of the vitrified borax, incident to the soldering, are removed, or it may be put into a small copper vessel, partly filled with the same solution, and boiled for a few minutes. After removing the plate from the acid, it should be boiled for five or ten minutes in a solution of chlorid of soda or common salt and water to remove thoroughly all traces of the former.

The Finishing Process.—Superfluous portions of solder are now to be removed, and this at first may be more quickly accomplished by the use of burs of various forms and sizes attached to the dental engine. After the rougher and more redundant parts are thus cut away, any remaining irregularities upon the surface may be further reduced with properly formed stones and disks. Then with a rapidly revolving brush attached to a foot-lathe, the final polish or luster may be imparted by the use, first, of Spanish whiting, or prepared chalk, and then rouge mixed with water or alcohol.

In the final adjustment of the finished piece to the mouth, and

after any additional change in the form of the teeth necessary to secure the most perfect antagonism has been made, the patient should, in all cases of partial dentures, receive explicit directions in regard to the general care and management of the appliance and the remaining natural teeth. Ordinarily, there will be but little difficulty experienced by the patient in the immediate and successful use of a substitute supported in the mouth by clasps, or any equivalent means, but in the case of atmospheric-pressure plates, the patient should be candidly advised of the probable want of stability incident to the first use of the appliance, and the consequent annoyance which in many cases follows its occasional displacement in mastication until such time as the adaptation of the several parts to each other are perfected, and the patient has acquired a habit of controlling and directing the forces applied to the substitute. The time necessary to accomplish these results will depend much upon the form and condition of the mouth, a favorable or unfavorable antagonism, the adaptation of the plate, and the aptitude and temper of the patient. It will be prudent and but just to the patient to state that the complete utility of an appliance sustained by atmospheric pressure will not, probably, be realized in less time than from one to two weeks, and this estimate of time, in a majority of cases, will be fully justified by experience in the cases under consideration.

The importance of thorough and absolute cleanliness of the substitute and remaining natural teeth, and the reasons therefor, should be clearly stated; and the comfort, utility, and durability of the artificial fixture, as well as the safety of all the remaining natural organs, will depend, in a great measure, upon the fidelity of the patient with respect to the observance of these injunctions. In those cases especially where clasps are used, the substitute should invariably be removed after each meal and cleansed, while the teeth clasped should, at the same time, be freed from deposits of food or other foreign substances with a brush, and other means usually recommended for the purpose.

CHAPTER IX.

ENTIRE DENTURES.

Before proceeding to describe in detail the mechanical processes or manipulations concerned in the construction of entire dentures, unnecessary repetition will hereafter be avoided by first considering in this place certain underlying principles and fundamental requirements which are common to all the various distinct methods of replacement in edentulous cases. This preliminary treatment of the subject may be comprehended under two general heads: (1) a consideration of the principles and attendant phenomena involved in the application of the forces commonly utilized as a means of attachment; and (2) esthetic requirements in the selection and arrangement of the teeth of replacement. There are two forces in nature utilized in the retention of entire dentures, notably in upper cases,—*Atmospheric Pressure* and *Adhesion*. We shall consider, first, some of the attributes and phenomena characteristic of these forces, and then endeavor to make some practical application of them in elucidation of the subject in hand.

Adhesion may be defined as the force by which the particles of different bodies stick together, in contradistinction to cohesion, which is the force that holds the molecules of the same body together. There are a number of different kinds of adhesion, but our present purpose only contemplates those which relate to the adhesion of solids to solids, and fluids to solids.

The adhesion of solids to solids is illustrated by pressing together two plates of glass or metal having perfect occluding surfaces, when they will be found to adhere with force enough to support not only the lower plate, but some additional weight. Very delicate tests have been made by which the adhesive force is accurately measured. An important practical fact, in this connection, has been well established, which has a direct bearing on the subject we are considering, namely, that the tenacity

with which such plates adhere to each other is not in any manner due to, but wholly independent of, any force exerted by the pressure of the atmosphere, as was supposed by some of the earlier experimenters. The fact alluded to was conclusively proven by suspending the plates, the lower one of which was weighted, in the vacuum of an air-pump, in which case the plates still remained adherent. Examples of this adhesive force as affecting solids might be almost indefinitely multiplied.

The force of adhesion of solids to liquids is not less pronounced. When a polished plate is suspended on a delicately constructed balance, and brought carefully down on the surface of a liquid, completely excluding the air, adhesion will take place, the force of which will be modified by the kind of liquid in contact with the plate. It has been ascertained by careful experiment that the adhesive force of a polished plate of agate, one inch in diameter, in contact with water, is 25 grains; sulphuric acid, 29; hydrochloric acid, 25; solution of saltpetre, 23; of lime, 21; almond oil, 16; petroleum, 16; turpentine and alcohol, 15; ether, 10. Where, as often happens, drops of the liquid adhere to the plate when separated, it proves that the adhesion of the liquid to the solid is stronger than the cohesion of the liquid itself, and that the numbers obtained in these experiments express rather the cohesion of particles of the liquid which were separated by the weight, than the adhesion of the plate to the liquid. As in the case of adhesion of solids to solids, it was formerly claimed by some that adhesion in these cases was due to atmospheric pressure, but that was disproved in the same manner as the other. Perfect exclusion of air is essential to the operation of this force, a suggestive fact in connection with the adaptation and retention of entire dentures.

Atmospheric Pressure is that force exerted by the air by reason of its gravity, one of its mechanical properties being *weight*, which renders it amenable to the same law of attraction that affects all other bodies similarly endowed. It exerts a pressure not only downward, but, according to the law of fluids, sideways, upward, etc., as by the mobility of fluid particles any pressure is transmitted in all directions. Superadded to gravity is its elastic force, a property which, like all gaseous bodies, it

possesses in a remarkable degree. This property is familiarly demonstrated by filling a bladder with air and exposing it to rarefied air at a great height. The external pressure of the atmosphere at such an altitude being diminished, the air within tends to expand to the same degree of rarity as that without, and with such force as to burst the bladder. The partial displacement of air by compression within a diving-bell by the pressure of water at a low depth, and the forcible expulsion of the intruding water as the bell is brought to the surface, not only illustrates its elasticity, but its impenetrability also, or its property of preventing another body from occupying the space where it is. There are many other examples of the pressure of the atmosphere and the force exerted by virtue of its elastic property, but those of most interest and consequence to the prosthetic specialist relate to their effects on the human organism. It is estimated that the force exerted by the pressure of the atmosphere on the body of a medium-sized man must be about fifteen tons, a force sufficient to crush and destroy him if applied only to the external portions of the body. Such pressure, however, is neutralized and rendered harmless by counter-pressure from within; a result due to the elasticity of the air, which exerts a force everywhere and *in all directions alike*, from the external parts inwardly, and from those within outwardly. The tendency in nature everywhere is toward the establishment of an equilibrium of atmospheric pressure, and when these balanced forces are disturbed, unusual and characteristic phenomena follow. If, as in the case of "cupping," the external pressure of the atmosphere is removed by the formation of a vacuum, the elastic force of the air operating from within, and meeting no counter-force at the point cupped, will, by virtue of its inherent elastic energy, force the soft tissues into the body of the cup as the result of this tendency to an equilibrium. The latter occurs as soon as the unoccupied space forming the vacuum is filled with the tissues, when, the accustomed balance of forces being restored, the cup will loosen and fall off. If the disturbance of the equilibrium of forces acting from without and within is general, as in the case of an aëronaut in a balloon at great heights, the result of this tendency may, and often has, put life in jeopardy by expansion of the

internal organs. On the contrary, the body exposed to greatly increased external pressure of the air, as when the latter is condensed in the diving-bell at low depths, or in caissons employed in forming a foundation of subaqueous structures, the results may be equally harmful or fatal by compression of the internal organs.

The Application of Atmospheric Pressure and Adhesion in the Retention of Artificial Dentures.—Let us now make some brief application of the above well-established facts in explanation of the manner in which atmospheric pressure and adhesion act as forces in the retention of so-called "Atmospheric-Pressure Plates," and the phenomena and results of such action.

This discussion may be premised with the statement of the general proposition that, in the case of entire dentures, retention of the plate in place by atmospheric pressure presupposes a *vacuum* obtained by exhaustion of the air from a *cavity*, of whatever form, located somewhere between the plate and the mucous surfaces on which the latter rests, and that such cavity implies *space*. Whenever, therefore, a dental appliance of the kind under consideration is in uniform contact at all points with the parts in the mouth, it is manifestly improper to speak of it as being held in place by atmospheric pressure, or to designate it as an "atmospheric-pressure plate." Uniform contact implies perfect continuity between the plate and the parts on which it rests, and this necessarily precludes the idea of space, and without space a vacuum is impossible, and in the absence of the latter, the atmosphere, as we shall endeavor to show, is wholly inoperative as a retaining force. To comprehend the matter intelligently, we must not lose sight of the important central fact that the atmosphere, in its undisturbed condition, exerts an equal pressure in all directions, a property largely due to its elasticity, and that in obedience to this law, in its operation upon the human organism, the force exerted from without inward is exactly counterbalanced by the same force acting from within outward, thus establishing an equilibrium of the counteracting forces, and a consequent neutralizing of pressure at the surface. This equalized force is an essential condition of human well-

being and of human life, as has been heretofore stated and demonstrated by examples. The absurdity, therefore, of attributing the retention of substitutes, adapted in this manner to the mouth, to the pressure of the atmosphere is apparent. There can be no reasonable question but that substitutes so applied are held *in situ* by that force manifesting itself in *Adhesion*. In all cases where the plate or other base is accurately adapted to the entire mucous surfaces, and the air thoroughly excluded, the essential conditions favoring its retention by adhesion is secured, namely, perfect contact of a solid with the fluids with which the mucous surfaces are constantly bathed.

Let us now consider, as briefly as possible, the manner in which air-pressure acts as a retaining force when applied to cavity-plates, and in the same connection some of the phenomena resulting from such action.

When a plate, provided with a cavity or chamber, is applied to the mouth, two concurrent phenomena are observed—the immediate and forcible attachment of the plate to the mucous surfaces, and the obtrusion of the soft tissues into the space from which the air has been exhausted. The first is due to the external pressure of the atmosphere, the latter to the same force acting from within. Here, again, it is essential to remember the fundamental fact that atmospheric pressure acts equally in all directions. In the case of the human body, as before stated, the pressure of the air from without inwardly is exactly counterbalanced by the pressure of the atmosphere within outwardly, establishing in this manner an exact equilibrium of forces, the one neutralizing the other at the surface. The phenomena to which attention has been called, in the case of an applied cavity-plate, are the result of a disturbance of these ordinarily balanced forces. When a vacuum, partial or complete, is formed by exhaustion of air from the chamber, the external pressure of the air meeting with a diminished counter-resistance from within, by reason of the vacuum, forces the plate against the parts, while at the same time the atmospheric pressure acting from within outwardly, meeting with a like diminished resistance at the surface embraced within the limits of the chamber, forces

the soft tissues into the chamber. Thus we find displayed the universal tendency to an equilibrium of atmospheric pressure, and a practical illustration of nature's proverbial abhorrence of a vacuum.

It is not probable that a perfect vacuum is ever secured by the means ordinarily employed by the patient, unless, perhaps, in the case of very shallow cavities. The moment any portion of the contained air is exhausted, there is instant and forcible pressure of the plate upon the soft tissues immediately surrounding the chamber, acting as an effectual mechanical impediment to farther egress of air. The power to exhaust is therefore self-limited, and a partial vacuum only the result. Sooner or later, in a large percentage of cases, even this limited power is rendered inadequate to secure any degree of exhaustion by the intrusion of tissues which, by long-continued and unrelieved pressure, become in time permanently hypertrophied.

The completeness with which the chamber may become filled with soft tissues will depend partly upon the form of the cavity, and partly upon the abundance and mobility of the tissues. If the cavity is constructed with vertical walls and sharply-defined margins, the latter, by becoming quickly imbedded, will act as a mechanical obstruction to any ready, sliding movement of the tissues into the chamber. Plates so constructed adhere with greater tenacity and more persistency, especially when the parts embraced are rigid and immobile; but it is at the cost of the maximum of injury which cavity plates are capable of inflicting, and which is often, in extreme cases, characterized by rupture of the superficial vessels, wounding of the mucous membrane, and in active inflammatory conditions which not infrequently involve the adjacent tissues. More ready entrance of the tissues into the chamber occurs where the edges of the latter are rounded and the walls slope toward the center, as in the case of those that are swaged, but this form is at the expense of the retaining force, since atmospheric pressure from without is always diminished in proportion as the cavity becomes filled in with the tissues, and ceases entirely when a vacuum no longer exists. The facility with which the chamber will become occupied is greatly increased when the soft tissues are in excess,

their softness and mobility offering but a feeble resistance to the atmospheric pressure from within, in which case the cavity soon becomes partly or wholly occupied by them, and what retaining force was originally secured by atmospheric pressure will, in a comparatively short time, become greatly impaired or wholly inoperative.

In addition to the force acting from within, tending to weaken the attachment of a cavity plate by filling in the chamber with soft tissues, there is another force, acting mechanically, which contributes in no inconsiderable degree to the same result. On exhaustion of the air from the chamber, the plate, being pressed with considerable force against the mucous surfaces, will exert a corresponding pressure upon the tissues immediately surrounding the chamber, the mobility of which admits of more or less displacement, and as this always occurs in the direction of the least resistance, they readily enter the cavity.

When it is remembered how inadequate and transitory are the uses of so-called "air-chambers," and how capable, under ordinary circumstances, they are of inflicting serious and permanent injury upon the delicate tissues of the mouth, there would seem to be no sufficient reason or justification for their employment, except possibly in rare and exceptional cases. *Experience has amply demonstrated that equally secure and much more enduring attachment of the substitute may be obtained in the utilization of adhesive force alone*—a means of retention wholly exempt from the harmful consequences that too often follow the application of atmospheric pressure consequent on the formation of a vacuum.

There are, however, many cases where spaces or cavities may be employed to advantage for the purpose of securing, through the temporary pressure of the atmosphere, increased stability of a dental appliance subjected to the forces applied in mastication. There are associated conditions of the mouth which, in their normal and undisturbed relation to each other, prevent, to some extent, a uniform or equalized bearing of the substitute upon the parts to which it is applied. These conditions relate to unequal hardness and softness of the tissues, and a consequent inequality of resistance to pressure. Thus, if the ridge is relatively

softer and more compressible than the central portion of the arch, the plate, when force is applied over the ridge, will " ride " upon the central portion, as upon a pivot-point, and thus raise or detach the plate from the ridge on the opposite side. This is called " rocking " of the plate, the action being illustrated in the sport familiarly known as " see-sawing." *The remedy for this consists in securing a space between the central portion of the roof of the mouth and the corresponding portions of the plate, so that when the substitute is applied to the mouth and the air exhausted, the greatest pressure will be expended upon the ridge, and, by compression, equalize the resistance.* This space, when the plastic vegetable bases are used, is obtained by scraping away from the impression at the required points ; raising the central portions of the plaster model with sheet-lead of proper form and thickness ; or by trimming away from the palatal surface of the finished piece. In the case of swaged plates, the shrinkage of the metallic die will ordinarily afford the required space.

In cases where there is approximate uniformity of hardness of the ridge and central line of the arch extending antero-posteriorly, associated with soft and yielding tissues filling the fosses on either side and extending some distance up the lateral walls of the arch, it is customary, in order to equalize the pressure of the plate, or, rather, to secure uniformity of resistance to such pressure, to scrape away from such portions of the plaster model as correspond with the softer tissues, thus securing in the finished piece an increased convexity or fulness which, on application of the substitute, exerts a compressing force at such points superadded to that obtained either by atmospheric pressure or adhesion. It may be reasonably objected to this mode of procedure that the augmented compressing force thus applied, being continually antagonized by the inherent elastic force of the tissue pressed, must inevitably tend to weaken the attachment of the substitute, and that such repelling force will continue to act, in a diminishing degree, no doubt, until, from long-continued pressure, such of the tissues as are not displaced will become absorbed or atrophied. The objection is emphasized by the further fact that, in such cases, the absorption is always preceded and accompanied by forcible displacement of superabundant tissue

into the soft palate, inducing more or less irritation and ultimate chronic tumefaction of the displaced tissue at the posterior margin of the plate. The prevalent fallacy that the tissues thus subjected to pressure are *condensed* thereby has been considered in the initial portion of the chapter on impressions.

No device will, we believe, so effectually and satisfactorily fulfil the requirements of the cases last mentioned as the one that provides for displacement of the tissues within the limits of the plate itself. This may be done by securing a graduated space including a large part of the palatal vault. This space should not be in the form of a cavity with defined walls, but should slope gradually toward the periphery in such manner that its boundaries shall be undistinguishable. By a graduated cavity is meant that, wherever the soft tissues are in excess, there should be a corresponding depth of space to provide for such varying degrees of displacement as are essential in the procurement of an equalized resistance to the pressure of the plate. By this method, there is not only no injury or objectionable deformity inflicted, but the attachment of the substitute, instead of being impaired, as in the other method, is maintained at first by the full and unobstructed force of atmospheric pressure, and when, finally, the required displacement of tissue is accomplished by a filling in of the space, the best practicable adaptation is obtained, and the future stability of the substitute as perfectly provided for as is possible with the resources at our command.

Esthetic Requirements in the Selection and Arrangement of the Teeth of Replacement.—In selecting teeth for an entire upper and lower denture, the special requirements in respect of size, form, and color will depend in a great measure upon the complexion, age, sex and general configuration of the face of the patient. Every separate denture, therefore, that is constructed in strict conformity with a faithful interpretation of the special requirements of each individual case, will be characterized by shades of differences in color, form, size, and arrangement of the teeth of replacement. The indication in the fulfilment of such requirements, broadly stated, is, that such selection of the teeth, in any given case, should be made as will, when suitably arranged, most perfectly reproduce the lost pro-

portions of the facial contour, and restore the characteristic expression of the individual.

To accomplish this with fidelity will require a higher order of intelligent discrimination, and a broader art culture than is required in cases where the operator is aided by comparison of the artificial with remaining natural teeth, as in partial dentures. In the present case he has no resources except those that come to him through a critical and conscientious study of the laws of harmony as displayed in the typical forms of dentures associated with individual physiognomy and temperament. Says a thoughtful writer :* "We find that the necessity for art in dentistry exists in proportion to the hopelessness of the case. The greater the amount of lost tissue to be replaced, the greater the knowledge of *natural* form required to properly effect its replacement. Beginning with the restoration of portions of teeth through gold fillings, we come to the loss of the entire crown, and, finally, to that last resort, the replacement of the entire denture. Knowledge of form and color, of expression, character, and effect, now becomes imperative to the dentist. To relieve the condition of his patient, the art of the sculptor and colorist must be studied with more care than many of us are wont to give it, while a knowledge of temperament and physiognomy becomes an important element in our work."

"No matter how anatomically correct," observes one of the most intelligent contributors to the literature of esthetic dentistry,† "or how skilfully adapted for speech and mastication, an artificial denture may be, yet, if it bear not the relation demanded by age, temperament, facial contour, etc., it cannot be otherwise than that its artificiality will be apparent to every beholder.

"This law of correlation, harmony, running through nature, attracts and enchants us by an infinite diversity of manifestations ; the failure to recognize its demands by art is correspondingly abhorrent to our sensibilities.

"In the social gathering, a lady who appreciates the law of

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* Dr. Eben M. Flagg, *Dental Cosmos*, March, 1881.

† Dr. James W. White, "The Teeth."

harmony delights the eye by the taste displayed in her attire, another, though more elaborately and expensively adorned, yet failing to harmonize the details of her costume, attracts attention only by the impression of incongruity. We hear frequently from a lady who is selecting a bonnet, or from a gentleman purchasing a hat or other article of wearing apparel, the question to a friend, 'Does this become me?' the query indicating the recognition that, however exquisite the material or excellent the manufacture of the article, a certain law of fitness prevails, the failure to comply with which makes the wearer appear ridiculous. We meet in the street one the color of whose hair we expect, by the law of association, to be fair or sandy, and if otherwise, a wig or a dye is instantly suggested.

"There is a relation between the physical form and the voice, from which we are led to infer in advance the character of the tones which from any given individual may be expected. This law of association in any case having led us to anticipate a bass voice, the anomaly, should a falsetto greet us, is almost ludicrous.

"There is a similar relation between other physical characteristics and the teeth. A broad, square face, or an oval; a large, coarse-featured man, or a delicately-organized woman; a miss of eighteen or a matron of fifty; a brunette or a blonde,—these and other varieties present as many differing types, with teeth, in size, shape, color, density, etc., corresponding. If, then, teeth correlated in their characteristics to those which nature assigns to one class be inserted in the mouth of one whose physical organization demands a different order, the effect cannot be otherwise than displeasing to the eye, whether the observer be skilled in perception, or intuitively recognizes inharmony without understanding the cause."

Written or verbal instructions can do little more than present general principles governing the selection of teeth for any given case. The completeness with which the requirements of individual cases are fulfilled will largely depend upon the operator's art intuitions, and his ability to properly interpret and apply the basal facts which an intelligent study of the relation of physiognomy and temperament to the teeth has revealed. The relations of the latter to the teeth have been clearly and fully set forth in

tabulated form by Dr. J. Foster Flagg, which we herewith append. The first table relates to the basal temperaments, namely, bilious, sanguineous, nervous, and lymphatic, and their general indications; the second, to the teeth as indicated by temperament.

A careful study of these tables, the subject-matter of which is by far the most valuable contribution that has yet appeared in connection with the subject under consideration, will furnish whoever avails himself of its practical suggestions a helpful means of solving one of the most difficult problems in prosthetic practice.

The following editorial, by Dr. James W. White, on "Temperament in Relation to Teeth," suggested, doubtless, by Dr. Flagg's tables, embodies not only a discussion of the general subject of temperaments, but some forcible and striking commentaries on the importance and value, esthetically considered, of the indications furnished by temperamental characteristics in the intelligent choice of artificial substitutes for special cases. The importance of the subject to which the article relates will justify its introduction here without abridgment:—

"The animal kingdom is divided into sub-kingdoms, classes, orders, families, genera, species. A further or sub-division includes in minor groups individuals whose salient characteristics are correspondent or similar. Thus every living creature has certain physical peculiarities by which its position in this classification is determined. Man, as the head of the animal kingdom, besides having his place in this general scale, is distinguished by a still finer classification under the denomination of temperament —an association of several distinguishing characteristics, such as size and form of body, complexion, color of the eyes and hair, and, to a certain extent, the disposition and character of the individual.

"Temperament may be defined as a constitutional organization, depending primarily upon heredity—national or ancestral —and consisting chiefly in a certain relative proportion of the mechanical, nutritive, and nervous systems, and the relative energy of the various functions of the body—the reciprocal action of the digestive, respiratory, circulatory, and nervous systems. The stomach, liver, lungs, heart, and brain—diges-

THE FOUR BASAL TEMPERAMENTS AND THEIR GENERAL INDICATIONS.

	Indications.	Bilious.	Sanguineous.	Nervous.	Lymphatic.
1	General Form or Framework,	Tall, angular, massive; square built.	Full, firmly-rounded contour development; medium height; robust.	Delicate; slight, but erect and well-proportioned.	Bulky; heavy; clumsy.
2	General Movement,	Steady and persistent.	Full, graceful and easy.	Rapid but fitful in movements; quick in the sense of frequent.	Unsteady; uncertain, loose-jointed; sluggish; deliberate.
3	Muscular Development,	Knotty: prominent; hard; tense; well-developed.	Well-rounded and graceful.	Well-defined; light, but sinewy.	Large, but flabby and ill defined.
4	Chest or Thorax,	Square and capacious; good expansive power.	Well-rounded and capacious; deep and full.	Not broad but prominent; very expansive.	Large, but lacking in expansive power.
5	Voice, Quality of,	Strong, but inclined to harshness.	Smooth; sonorous; full.	Not very strong, but clear, penetrating and ringing.	Poor in vibration, but often soothing and quieting in quality.
6	Complexion and skin,	Brownish-yellow; tense, and inclined to roughness; dry.	Florid; smooth; warm and dry.	Abounding in grayish tints; fine in texture, and elastic.	Pallid; muddy; moist and cold.
7	Favorable Endowments or Advantageous Indications,	Strength; endurance; fortitude; decision; firmness.	Hopeful; enthusiastic; aspiring.	Remarkable recuperative power.	Gift of self-control; calm; cool; quiet.
8	Unfavorable Endowments or Disadvantageous Indications,	Inclined to melancholy; despondent.	Lack of self-control; impetuous.	Mental fitfulness, and inclined to rapid degeneration or retrogression.	Inertia; low recuperative power in pathological conditions.
9	Cranial Contour,	Square forehead and cranium.	Rounding and full forehead and cranium.	Cranium inclined to preponderate over face.	Forehead low and not shapely; often receding and flat.
10	Facial Contour,	Angular; high cheek-bones.	Round and full.	Delicately oval.	Flat-faced.
11	Hair,	Black, and closely curling; inclined to coarse.	Golden to light chestnut; slightly wavy.	Brown; wavy; fine.	Coarse; straight; drab, and sparse.
12	Eyes,	Average size; black, and strong in expression.	Large; full; clear; round; blue.	Above average in size; dark brown; perceptive in expression.	Small, expressionless, and grayish.
13	Eyebrows,	Heavy; strong and straightly marked.	Fairly arched; not well-marked.	Well-marked and arched; finely penciled.	Sparse and indistinct.
14	Nose,	Strong in outline; Roman.	Straight and shapely.	Finely cut and often delicately aquiline in form.	Flat; alæ heavy.
15	Lips,	Large, and brownish-purple.	Ruddy and full.	Fine and grayish-pink.	Large, but not shapely, and pale.

THE TEETH AS INDICATED BY TEMPERAMENT.

General Divisions.	Bilious.	Saguineous.	Nervous.	Lymphatic.
General Color and Quality of Color, .	Bronze-yellow, with strength or power of coloring.	Cream-yellow, and inclined to translucency.	Pearl-blue or gray; inclined to transparency.	Pallid and opaque, or muddy in coloring.
General Form, . .	Large and inclined to angular; rather long in proportion to breadth.	Well proportioned; abounding in curved or rounded outlines; cusps rounding.	Length predominating over breadth; fine, long cutting edges and cusps.	Large, but not shapely; breadth predominating over length; cusps poorly defined.
Surfaces of the Teeth	Inclined to transverse ridges, and abounding in strong lines; neither brilliancy nor transparency of surface, but slight translucency.	Smooth, or nearly so; elevations and depressions rounded; cutting edges and cusps translucent. Fair degree of brilliancy.	Brilliant and transparent depressions and elevations; abounding in long curves.	Surfaces of incisors devoid of depressions or elevations; opaque and dead in finish, even to cutting edges.
Articulation, . . .	Firm and close; well locked.	Moderately firm; jaw inclined to rotate in mastication.	Very long and penetrating.	Loose and flat.
Gum Margin or Festoon, . .	Heavy and firm, but inclined to angularity.	Round and full, as regards both breadth and depth.	Delicate, shapely and fine; oval in curve.	Thick and undefined in shape.
Rugæ, ...	Heavy and rugged in shape; squarely set.	Numerous and graceful in outline; not heavy, but well rounded.	Close, not numerous; small and long.	Sparse and flat.

tion, assimilation, respiration, circulation, and innervation—are all factors in the differentiation of temperament; and according to the congenital predominance of one or the other, and the relative activity of these functions, is the modification of the characteristics of the individual which assigns him to one or other of the basal or mixed temperaments. Each temperament is the result as well as the indication of the preponderance of one or another of these systems, and of relative functional activity.

"A perfect equilibrium of the different systems is rarely, if ever, presented in any individual. One having a balance of all the temperaments would be temperamentless, or of no special temperament. It is difficult, in some cases, to decide positively to which variety a special case belongs, the several temperaments being combined and blended in such ever-varying proportions. Not infrequently the indications are even contradictory, and the blending of several temperaments require a nice discrimination to define the admixture. The primary elements of temperament are susceptible of such manifold combinations; the determining forces are so complex, and our knowledge of their comparative values is so limited, that no rule can be given which will not fail in numerous instances to apply in all respects to individual cases; but that there is a general relation between constitutional qualities and external signs does not admit of question.

"Temperaments are readily divisible into four basal classes—bilious, sanguineous, nervous, and lymphatic (see tables); then again into sub-classes of mixed temperaments—a combination of two or more of the primary divisions. In these combinations one or other of the so-called basal temperaments predominates, and a compound term is used to express the complexity, as, for instance, the nervo-bilious, signifying that the bilious base—the foundation temperament—is qualified by an admixture of the nervous element, and so throughout the series. Twelve varieties of temperament, in addition to the four basal, may thus be designated by the combination in pairs of the original four. The admixture of the peculiarities of three or of all four of the basal temperaments results in what are denominated respectively

ternary and quaternary combinations, which call for nice discrimination in diagnosis; but even such complexities are registered in the size, form, and color of the dental organs.

"The value of a practical application of the study of temperament in the practice of dentistry is apparent. That the relation of the teeth to temperament is, as a rule, ignored by those engaged in prosthetic dentistry is evident in the mouths of a majority of those who are so unfortunate as to be under the necessity of wearing substitutes for lost natural dentures.

"A certain law of harmony in nature between the teeth and other physical characteristics necessitates respect to size, shape, color, and other qualities in an artificial denture, in order that it shall correspond with other indications of temperament; and if teeth correlated in their characteristics to those which nature assigns to one temperament be inserted in the mouth of one whose physical organization demands a different type, the effect is abhorrent. The artificiality of artificial teeth is the subject of remark by those who have little or no conception of the reason therefor—simply an instinctive appreciation of the incongruity and unreality. It is indeed rare to see a case in which there is occasion for a moment's hesitation as to the fact of replacement. There is no dental service that, from the esthetic standpoint, is, as a rule, so illy performed as the prosthetic. Thousands of dentures are constructed which serve the needs of the wearer for speech and mastication, but which are, nevertheless, deserving of utter condemnation as art productions. More attention has been paid to the best methods of restoring impaired function—securing comfort and usefulness in artificial dentures—than to a correlation of the substitutes to the physical characteristics of the patient.

"What is needed is such an appreciation of the law of correspondence that the dentist can cipher out, as by the rule of three, the character of teeth required in the case of an edentulous mouth with the same precision as the comparative anatomist can from a single bone indicate the anatomical structure of the animal to which it belonged. The probability is that in many, perhaps in most, of the cases of incongruous artificial dentures the fault is not in carelessness or indifference of the dentist, but

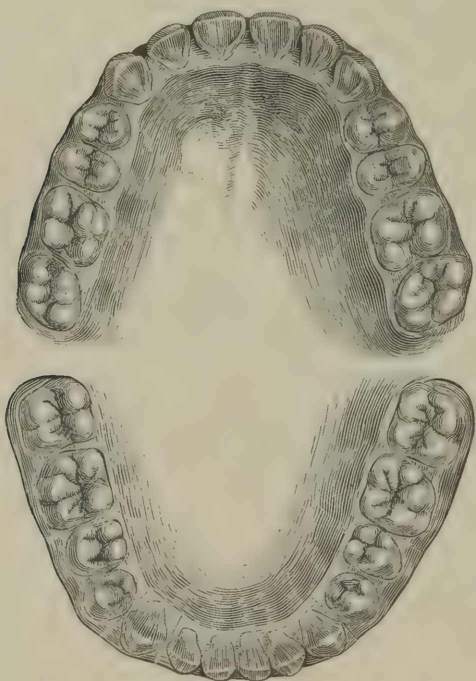
in failure to recognize the requirements of temperament. A certain family resemblance to each other in a set of teeth is considered essential, but the adaptability of the set as a whole to a given case should be esteemed of even greater importance. Especially is there a notable failure to recognize the color demanded by form. A set of teeth in which not only the relative length and breadth, but every line and curve, characterize it as belonging to a certain temperament, is, in contravention of every law of correspondence, made of a color which was never found in nature associated with such forms. Thus we see constantly such incongruities as the association of the massive tooth of the bilious temperament with the pearl-blue color belonging to the nervous temperament, and the long, narrow teeth of the nervous temperament of bronze-yellow color never seen in the mouth of any but those of a bilious temperament.

"The trouble is not with the manufacturers; they supply the demand. The fact is, the requirements of the law of correspondence have not been sufficiently studied by the profession. The first study of the dentist who aspires to the dignity of artist, when proposing to replace a lost denture, should be how to restore the natural appearance of his patient, and this can only be effected through an appreciation and observance of the temperamental characteristics and the law of correspondence or harmony. Age and sex may somewhat modify the requirements in a given case, but the basal fact on which he should proceed is temperament. A failure to recognize its demands will result in failure—from an esthetic standpoint. A knowledge of the distinguishing characteristics of the various temperaments and the style of teeth which conform to nature's type in the physical organization marks the difference between the dental mechanic and the dental artist."

The fulfilment of the highest art conceptions in the construction of entire dentures is far from being complete with the mere selection of teeth in conformity with temperamental and other indications. The essential preliminary step is concerned chiefly with the form and color of substitutes, but the highest attainments in the art of replacement can never be attained without an intelligent perception of the esthetic requirements which have

inseparable relation to the *arrangement* of the teeth selected in strict conformity with the same law of harmony or correspondence that applies to form and color. The art of arrangement is scarcely less difficult, and certainly not less important, than the art of selection, and equal judgment and discrimination will be required to effect such an adjustment of the teeth as will most faithfully serve to restore the facial contour and characteristic

FIG. 495.



expression of the individual. This will, in most cases, necessitate some deviation from the uniformly symmetrical or ideal relation of the teeth to each other characteristic of perfect regularity of arrangement, and which rarely exists except in connection with a perfectly balanced development of the jaws and teeth, a condition which may be said to be almost phenomenal. Such an arrangement is exhibited in Fig. 495.

The kind or degree of displacement of any particular tooth or teeth to effect such irregularity of arrangement as would best reproduce the customary expression of the individual in any given case, cannot, of course, be here indicated. The operator is necessarily thrown upon his own resources in determining, in this respect, the necessities of individual cases. Generally speaking, the changed relation of the teeth is, in most part, confined to the six anterior teeth, above and below, as they are most largely concerned in expression; but it may often be extended to the bicuspids and molars, which may be displaced within or without the arch, or given an oblique position, with here and there interdental spaces, some of which may be wide enough to suggest the loss of the natural teeth at intervals. The central incisors may be made to overlap each other, with the laterals in normal position; or the latter may be given a position inside of the circle, which will give a relative prominence to the centrals and cuspids, or they may be partially rotated while retaining their regular position in the arch, or be made to overlap or underlap the centrals, in which case the latter may be made to diverge somewhat from each other at the points, leaving some space between them.

There is scarcely any limit to the capability of effecting malpositions of the teeth or replacement, and this is especially true of those forms of substitution known as continuous-gum work, and in the use of celluloid, either process, by admitting of the use of single, plain teeth, affording unlimited opportunities for the optional placement of the teeth. In the use of sectional gum teeth, many of the forms of dental irregularity have been faithfully reproduced by manufacturers, and, when selected with an intelligent apprehension of their fitness for any particular case, will meet the ordinary wants of the practitioner in the use of rubber, or a metallic plate-base with rubber or celluloid attachment. The minimum of capability in effecting irregularity of arrangement is attached to soldered work, where, as is usually the case, single gum teeth are employed.

It is possible often, when teeth have been selected conforming as nearly as practicable to the requirements of the case in color, to so change the form of the teeth by judicious grinding of the

proximate surfaces, cutting edges of the incisors, and the points of the cuspids, and occluding surfaces of bicuspids and molars, as to greatly change the effect in the mouth, giving them an harmonious expression impossible in the use of manufactured teeth in their unchanged form. This is particularly observable when they are ground in imitation of the partial destruction of the occluding surfaces by erosion, a condition very commonly associated with middle age. The effect is still further enhanced by coloring the portions of the ground surfaces in imitation of the dark discoloration usually associated with exposed dentine. This may be readily done in the manner described in the chapter on partial dentures mounted on metallic plate-base. The same process of coloring may also be applied to single porcelain teeth representing absorption or recession of the gum at the cervix, which is always of a darker hue than the crown. An additional device, sometimes employed to disguise the fact of artificiality, is that of introducing gold fillings into one or more of the front teeth. Cavities for this purpose are sometimes formed in porcelain teeth at the time of baking. When these are not readily procured, the operator may easily improvise them. A dovetailed slot may be ground in the proximate side of a front tooth with suitably formed corundum-disks, or a concave depression made and retaining pits formed with a hard-tempered steel drill. A correspondent of the *Cosmos* gives the following method of using the drill: "Use a hard-tempered, spear-pointed steel drill in the engine, and while operating keep wet with a solution of spirits of camphor and spirits of turpentine in equal parts. The cutting will be facilitated by giving the hand-piece a slight rotary motion. If a contour filling is desired, grind off with the corundum-wheel as much as is desired for 'contour,' after which make the retaining portion with the drill." Cavities, however, can be formed with greater facility in the use of the diamond point.

With these general reflections concerning full dentures, we return now to a consideration of the mechanical or manipulative processes concerned in the construction of an entire denture attached to a swaged metallic plate by soldering.

CHAPTER X.

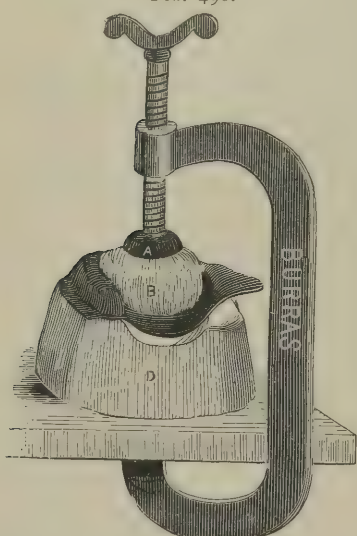
ENTIRE DENTURES ATTACHED TO A SWAGED METALLIC PLATE-BASE.

Method of Constructing an Entire Upper Denture Mounted on a Swaged Metallic Plate-Base.—The general form and dimensions of the required base to be used as a support for a complete denture for the upper jaw may first be indicated by drawn lines upon the plaster model, and a sheet-lead pattern obtained from this is to serve as a guide in securing the form of the plate to be swaged. The plate should be made sufficiently ample in its dimensions to cover all the hard palate, the alveolar ridge, and all portions of the external borders of the latter not directly encroached upon by the muscles and reflected portions of the mucous membrane of the lips and cheeks.

Before swaging, the plate should be well annealed, and its central portion brought as nearly as possible to the form of the palatal face of the die with the mallet, forcing the heel of the plate down in advance of the portion covering the more anterior concavity of the arch, preventing thereby a doubling of the posterior edge of the plate upon itself. This central portion may also be forced more perfectly into adaptation with a partial counter (see progressive counter-dies, page 179) before swaging in the ordinary manner, and this is advisable in all cases when the palatal arch is very deep; some operators, however, use the contrivance invented by Dr. T. H. Burras, of New York, illustrated in Fig. 496. The die and plate, as will be seen, are placed near the edge of the bench, and the upper part of the clamp adjusted over the central portion of the plate; the two pieces are then boundly firmly to the bench by tightening the screw. A protective piece of buckskin, cloth, or paper should be placed between the plate and the clamp to prevent the former from being bruised or indented. The margins of the plate are now

turned over upon the ridge, and if the external borders of the latter are undercut or stand even vertically, the edges of the former will tend to double upon themselves at such points, and hence it will be necessary, before swaging, to split the plate in front, and, in some cases, on each side, and wherever divided, a V-shaped piece may be cut out, of sufficient width to allow the divided edges to overlap slightly when approximated in the process of swaging. The proximate edges of the divided sections should be filed to a thin edge before swaging, so that when brought together and soldered there will be but little additional thickness of the plate at such points. The cut portions should not be soldered until after a partial or complete swaging.

Fig. 496.

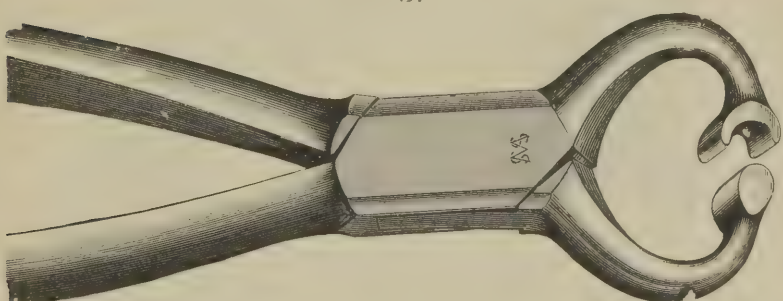


Having conformed the plate as nearly as practicable to the die with the mallet, or with plate forceps constructed for the purpose (Fig. 497), it should be placed between the die and counter, and the latter forced together with a heavy hammer until a tolerably accurate coaptation of the plate is obtained, the latter being frequently annealed during the process of stamping to render it more pliable. At first considerable yielding and consequent deformity of the counter-die will occur; hence, after partial swaging, another should be substituted and the process continued until the greatest possible accuracy of adaptation is secured. If the face of the die is marked by prominent and sharply defined rugæ, or other irregularities, such points will, to some extent, be bruised or flattened; it will therefore be expedient in such cases, and better, perhaps, in all, to finish the swaging with a new and unused die and counter, in which case two or three moderate, steady, and well-directed blows of the hammer will be sufficient.

If the plate is brought into uniform contact with all parts of the face of the die, this conformity is the only reliable test of its adaptation out of the mouth. In no case will the swaged plate fit the plaster model perfectly, inasmuch as the unavoidable contraction of the die, however slight, will, especially in deep-arched mouths, cause the plate to bind on the posterior and external borders of the ridge, preventing it from touching the floor of the palate; while the bruising, though inconsiderable, of the more prominent points upon the die, and a corresponding flattening of the plate at such points, will prevent uniform contact of the latter with the unchanged surface of the plaster model.

After final swaging, the plate should be again annealed with a heat nearly or quite equal to that which will be ultimately required

FIG. 497.



in soldering; after this, any additional swaging should be avoided, unless the plate warps in the heat, and which may be determined by applying it to the die; if any change has occurred, it should be reswaged and again annealed at a high heat, and the operation should be repeated, if necessary, until the plate retains its integrity of form after the last annealing. This process of final heating does not apply to silver if in the form of a swaged plate, as this metal invariably suffers some change of form when subjected to an annealing heat.

Modifications in the Form of Plates for Entire Upper Dentures.—Whenever a central air-chamber is employed, it may be constructed in either of the ways described when treating of partial atmospheric-pressure plates. The general form of an

entire upper denture with a central chamber, is exhibited in Fig. 498. Other modifications in the form of cavity-plates for full upper sets are in limited use, as where chambers are arranged one on each side of the sloping walls of the palate, or directly over that portion of the ridge previously occupied by the anterior molar and the bicuspids on each side, as seen in Fig. 499, called "Lateral Cavity Plates." Whatever their general utility may be, cases doubtless occur where they may be advantageously employed, separately, as shown in the illustration, or in combination with the central chamber, as when any great inequality exists in the hardness of the ridge and palate, such as cannot be readily overcome by ordinary means.

FIG. 498.

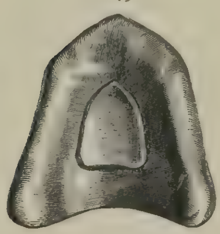
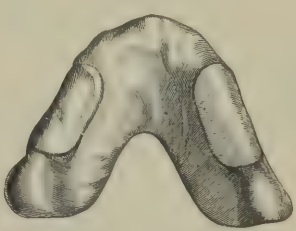


FIG. 499.



Forming the Borders of the Plate.—In whatever way the plate is formed, a notch or fissure of sufficient depth to receive and permit an unobstructed play of the frenum of the lip should be formed in the front part of the plate, while the borders of the latter nearly opposite the anterior molars on each side should be narrowed to prevent undue contact of its edges with the folds of the mucous membrane stretching obliquely across from the cheeks to the ridge. Care should also be taken to trim away from the heel of the plate any portions that might otherwise encroach upon the soft palate.

It is only in the fewest number of cases that a rim can be swaged to form a groove or socket properly situated for the reception of the plate extremities of either single gum or block teeth, as it will usually be found impracticable to adjust the gum extremities to the socket thus formed without necessitating,

in some degree, a departure from a just arrangement and antagonism of the teeth. Whenever it is thought best, therefore, to rim the plate, it will generally be necessary to adjust and solder a separate strip to the plate along its outer borders, and covering somewhat the gum portion of the artificial teeth resting on the plate, after the arrangement of the latter on the base is completed.

Trying the Plate in the Mouth.—After the plate has been worked as nearly as possible into the required form, it should be applied to the mouth of the patient to ascertain the correctness of its adaptation to the parts before proceeding further with the operation. If the adaptation is found imperfect, the fault lies either in the impression, or in undue contraction of the die. In the former case, another impression should be taken, and the plate re-swaged; in the latter, a less contractile metal or compound should be employed in the formation of the die. To determine the practical efficiency of the adaptation and adherence of an atmospheric-pressure plate, various tests may be applied. The coaptation of its borders to the external walls of the ridge may be ascertained by inspection, and the patient's sense of contact or non-contact of its central portion with the floor of the palate may, in some degree, be relied on as evidence of the accuracy of its adjustment to parts not visible. The tenacity with which the plate adheres on the application of direct traction cannot always be relied upon, inasmuch as a well-fitting plate will sometimes readily be dislodged in this manner, while, on the contrary, one but illy adapted to the parts may require considerable force to separate it from the jaw when acted on in the same way. *The most trustworthy test of actual or practical stability is firm pressure applied alternately over the ridge on each side and in front.* If the plate maintains its position and remains fixed under repeated trials of pressure applied in the manner indicated, the adaptation may be safely relied on; if it slides upon the palate or is easily disengaged from the mouth, the instability of the plate may be referred in many cases, not to a want of coaptation, but to a want of uniformity in the condition of the parts on which the plate rests. These conditions have already been sufficiently considered.

Method of Constructing an Entire Lower Denture Mounted on a Swaged Metallic Plate-Base.—Aside from the differences in the form of the plate, and the manipulations incident thereto, the process of constructing a plate for the under jaw does not differ essentially from that already described in connection with full upper dentures.

If the lower plate is constructed from a single lamina of gold or other metal, *it should be somewhat thicker than that used in upper cases, and should also be of finer quality*, as the additional thickness of the plate and the peculiar form of the inferior maxilla render a greater degree of pliancy necessary in swaging it to the form of the ridge. The general form of a base for an entire lower denture is exhibited in Fig. 500. The internal

FIG. 500.

FIG. 501.

border of the plate should usually be doubled—either by turning the edge over in swaging, or by soldering on a narrow strip of plate or half-round wire.

A more perfect adaptation of the plate to the ridge may be obtained by the use of a double instead of a single plate, in which case a thin plate, not exceeding No. 30 of the gauge, should be swaged to the form of the ridge in the first instance, and then a duplicate plate, swaging the two together and uniting them to each other with solder. A plate of the specified thickness may be very readily and accurately conformed to any irregularities in the ridge, and when the two are united the base will be heavier and stronger than a single lamina of the ordinary thickness. Instead, however, of doubling the entire

plate, it will be sufficient, in most cases, to adapt the second plate only to the lingual surface of the first, extending it up from the lower edge to a point corresponding as nearly as possible with the inner portions of the base of the teeth when the latter are adjusted to the plate (Fig. 501). A moderately thin plate may, in this manner, be used for the primary base, while the duplicate band will impart the requisite strength to the plate, and, at the same time, obviate the necessity of wiring its lingual border. In adopting either of the last-named methods, the plates after they are united to each other should be again swaged to correct any change of form incident to the use of solder.

Antagonizing Model for an Entire Upper and Lower Denture.—The following method is adopted in securing an antagonizing model for complete dentures:—

Attach to the ridge of each plate a roll or strip of adhesive wax corresponding in width to the length of the teeth which will be required for each plate respectively; place the plates with the wax attached in the mouth, and trim away from the proximate edges of the wax until the two sections close upon each other uniformly throughout the circle; then cut away from the labial surfaces of the rims of wax, above and below, until the proper fulness and required contour of the parts associated with the lips and mouth are secured. The approximation of the two jaws, when the finished substitutes are ultimately adjusted to the mouth, will depend altogether upon the aggregate width given to the two sections of wax at this stage of the operation, and it is, therefore, important that the "bite" or closure of the jaws secured at this time should be such as will most perfectly fulfil the requirements of the case in respect to the utility and comfort of the appliance, and the proper restoration of the normal facial expression. If there is any considerable change produced in the relation of the jaws habitual to them prior to the loss of the natural teeth, the characteristic expression of the individual will, in some degree, be changed or marred; an unaccustomed and restrained action will be imposed upon the muscles concerned in the movements of the lower jaw, which will render the use of the appliances at least temporarily, if not permanently, uncomfort-

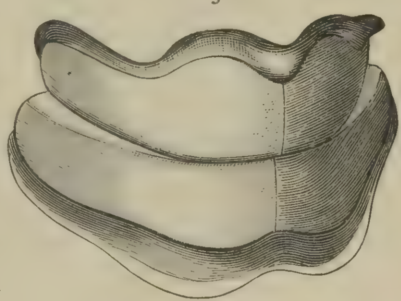
able and fatiguing, or even painful; while the utility of the fixtures may be impaired or wholly destroyed by compelling a particular application of forces in mastication inconsistent with their stability in the mouth. No specific directions, of course, can be given that will apply to all cases, but it may be observed that, ordinarily, the two sections of wax should be cut away from their approximating surfaces until the jaws close sufficiently to permit the edges of the lips to rest easily and naturally upon each other when in a relaxed condition, or the upper rim may extend somewhat below the margin of the upper lip, while the lower section of the wax is cut away on a level with the lower lip, or a little below it. Cases occur, however, where a less exposure of the upper portion of wax, even though quite narrow, will be required; as where the alveolar ridge is very deep, and the lip covering it either absolutely or relatively short, or where the latter is retracted, exposing, even when in a state of repose, a greater portion of all of the crowns of the teeth, and in extreme cases the margins of the gum. Between the latter extreme, and an inordinate extension of the upper lip below the ridge, all intermediate conditions occur, and the practitioner, aiming to produce an agreeable, harmonious, and truthful expression of all the parts, must rely wholly upon his judgment in reference to the necessary approximation of the jaws, the restoration of the natural fulness and contour of the mouth, and the relative length to be given to the upper and lower teeth.

Patients when requested to close the mouth *naturally* are very liable to *project* the under jaw; hence it is well to have them open and close the jaws frequently, observing at the same time if the separate portions of wax meet in precisely the same manner at each occlusion. If the bite varies at every approximation of the jaws, the patient should be directed to relax and abandon for the moment all control over the muscles of the lower jaw; the operator should then grasp the chin and press the jaw first directly backward and then upward until the opposing surfaces of the wax meet, in which position it should be steadily held by the patient until the two portions of wax are attached to each other in that particular relation. The latter may be done by drawing lines vertically across the rims of wax at various points,

which will serve to indicate their relation to each other when out of the mouth ; or a heated knife-blade may be passed between the two sections, the melted wax temporarily uniting them. A very convenient and secure method is to attach them together by means of two strips of metal bent in the form of a staple ; these may be warmed in a spirit-flame, and pressed into the wax, one on each side—one end penetrating the upper rim of wax, the other the lower. Before removing the plates, the mesial line of the mouth should be indicated upon the wax by drawing a line vertically across the latter in front, to serve as a guide in the arrangement of the central incisors.

The plates, *attached to each other* (as shown in Fig. 502), may be removed from the mouth, plaster mixed and poured into them to form temporary models for attachment in the articulator. When the plaster is sufficiently condensed, the line across the wax in front should be extended in a direct line across the borders of the plaster model above and below, as, in arranging the teeth, the wax will be removed, and without this precaution the mesial point of the mouth may be lost.

FIG. 502.

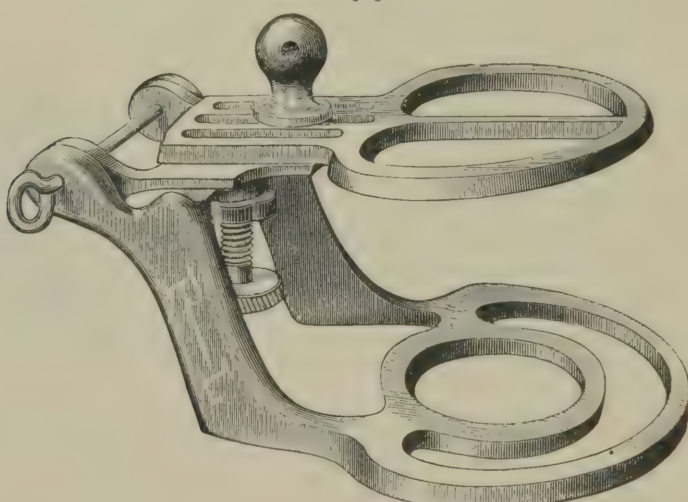


Antagonizing Model for an Entire Upper Denture with the Natural Teeth of the Lower Jaw Remaining.—In forming an antagonizing model to be used as a guide in arranging and articulating a full upper denture where all or a part of the natural organs of the inferior jaw are remaining, a rim of wax should first be adjusted to the borders of the plate, one or two lines wider than the required length of the artificial teeth. When placed in the mouth, the exterior surface of the wax draft should be cut away or added to until the proper fulness of the parts is restored. The patient should then close the lower teeth against the wax, *embedding them just sufficiently to indicate the cutting edges and grinding surfaces.* The median line of the

mouth is then indicated upon the wax and the plate removed, when the two casts (the lower having been previously secured from a wax or modeling compound impression), should be secured in the articulator shown in Fig. 491.

Articulators.—Various articulators have been devised. Fig. 503 illustrates one of the simpler forms, while a very ingenious and novel device has been brought to the notice of the profession by Dr. W. G. A. Bonwill, of Philadelphia, to which we give considerable space. The inventor has characterized it as the "*Anatomical Articulator*," and describes it as follows:—

FIG. 503.



"It is modeled on the same geometrical system as the human jaw.

"I found by measurement that the average width of the lower jaw from center to center of each condyle was four (4) inches, and from the same center of each condyloid process to the median line of the lower jaw, where the cutting edges of the lower incisors meet, was also four (4) inches, making of the human jaw an equilateral triangle. This holds good in all jaws, and the difference of a quarter of an inch in this radius of a circle of four inches would make but little practical difference as to the results.

"This beautiful law enables us to have the fullest benefit of mastication at the least expense of power and motion in the arc of the circle of four inches as a radius.

"This being an absolute law, I have so made this articulator, and the cast of every case is set therein with the median line at the lower centrals just four inches, by the dividers, from each condyloid process. If an unusually large jaw, then the cast is put a very little distance further out.

"For all full sets, the articulation is so perfect, as made in this, in the laboratory, as to need but a trifling touch in fitting in the mouth.

"I found that there is a further positive law in the mechanism of the human jaw that should be regarded in every substitute made therefor, and that is, just in proportion to the depth of overbite of the centrals, there is a curvature from the mesial surface of the first molars back, through the other molars, up the ramus. That this curvature upward and backward at the ramus is due solely to the depth of closure of the upper over the lower jaw. That where there is occlusion or closing of the cutting surfaces of the incisors directly upon each other, then a straight line, directly backward, is the consequence. If curved at the ramus, in such a case no lateral or forward movement of the lower jaw could occur—only the up and down.

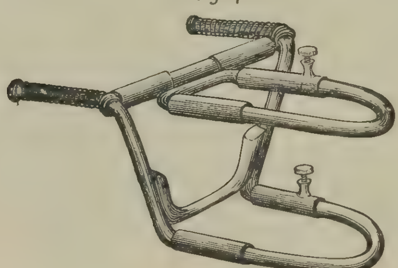
"When there is an eighth of an inch depth of bite, then, as you go back to the center of motion—the condyloid processes—the cusps in the bicuspids and molars grow less deep, and the curvature at the ramus is an eighth of an inch out of line.

"When there is an overbite of an eighth of an inch, then, in opening the lower jaw and carrying it forward to use the incisors for cutting, the back teeth of the lower jaw are brought forward; and as the second molar is higher out of line than the first molar, it comes in contact with the distal surface of the first superior molar, which begins just here to curve upward, and is the highest out of line in the superior jaw, and they meet at the same time that the incisors do. And the same law holds good when the lower jaw is turned to the right or left; the molars are brought in contact to equalize the force which would be brought upon the incisors only. Besides, the recognizing of this law

enables the cusps or palatal and lingual sides of the molars of both jaws to be utilized in every position the lower jaw may take in mastication. Upon this plan I make all my artificial dentures, most of their articulating surfaces being utilized at every position of the lower jaw. Any human jaw will show this system, which, by this system can be made just as complete, and more so, in many cases, than the normal, or such as is found in advanced civilization.

"When a set of teeth is commenced in this articulator with the upper overbiting the lower an eighth of an inch, as you set each tooth backward toward the condyloid processes they will assume the exact angle and depth of cusps, as well as the curvature at the ramus, as found in nature. If both jaws are in direct opposition

FIG. 504.



at the incisors, then all of the teeth must of necessity be on a perfect plane, or but one would touch when in lateral position.

"With this one base, which Fig. 504 shows, there is a separate bow to each part of base, one for upper and one for lower jaw, which can be removed as soon as the plaster in one case is allowed to harden on the rim. This can be marked and laid away for a year if necessary, and then articulated. A pair of bows can be used for as many separate cases, while only one base is required, which should be made absolutely and geometrically exact—approximately so.

"There is no need for set screws to hold the bows, as they go up just so far and remain so. Nor is there any set screw and prop to hold the jaws or casts apart. This is regulated on the bite in wax, which, before it is taken off the base plate, has the exact

height marked by a pair of dividers on the plaster at the median line, measuring from the cutting edge of wax, and then, when the first central or block is set, there is no longer any call for a prop to keep open the jaws of the articulator. When this height is taken with the dividers, it is marked on the top of each cast for future reference. It would interfere with the lateral movement if a rigid prop were there. The dividers make each case exact without a scale for measurement.

"Articulate the upper set first, and retain on the lower base the wax for length and fulness. When the upper are all on, then the lower incisors are gauged as to the height or length by the dividers while the wax is still on the base plate and taken from the height marked on the lower cast for reference.

"Make the lateral movement as soon as the first tooth or block is in position where the case is an upper one with a good lower jaw of natural teeth.

"When a full set, the upper are first ground on and shaped so as to meet the intended overbite, and when the lower set are ground on, the upper can be changed to suit the lower, so as to allow the whole of every cusp to touch at nearly every lateral movement of jaw.

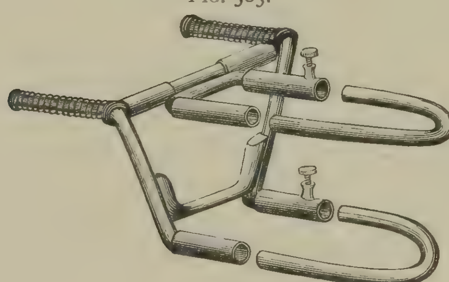
"When the plaster case is to be set in the articulator, it must be done with the dividers set just four (4) inches, with one point at the median line as formed by the lower incisors, and the other carried over to each condyloid process as marked on the articulator. This makes the center of jaw equidistant from the condyles. The study of this principle will make one fully realize the beautiful workings of Divinity, which is only governed by positive law in every department of the universe. With this plan understood, one will never again attempt to articulate a set of teeth on the unwritten law, as now universally made and recognized by every dentist in the land.

"Until this system is taught in the schools and by private practitioners, no truly artistic and fully natural set of teeth can ever be made, for we have been without law in this department. To describe it is not enough. It must be seen and demonstrated, one tooth at a time, until the whole set is made. Only in this way can it be understood.

"The Figs. 504 and 505 show clearly the simple construction. It is made of brass wire (one-eighth inch in diameter), and brass tubing to allow the size of wire to fit closely, and move freely therein when drawn out or pushed up. The spiral spring on either condyle allows of easy lateral motion to the lower part, and from exactly the same standpoint as in nature; that is, one of the lower condyles moves forward in the glenoid cavity while the other remains still. Every part of it is rigid except the movement at the condyles, and the joints or bows are only temporarily so. There is also an up-and-down motion made at the condyles by raising the bow up or down.

"No case, when once fixed in it, can become disarranged. If the bite in the wax is not correct, *no articulator can make it so.*

FIG. 505.



You must go back again to the mouth and retake it, which is easily done at first by asking the patient to swallow, when the jaws will automatically close and assume their normal position. If now correct, there is never any necessity for a screw to change it when once in this articulator.

"There can be no excuse for failure or unartistic work when this instrument is once understood and the law controlling the human jaw. As we may forever have to resort to artificial dentures, we should demand of the colleges that such an instrument be used, and it alone, as furnishing the only hope now offered of an approach to high-toned, artistic mechanical dentistry. Until we can be taught to appreciate that law is the governor of the universe, and applicable in every branch of dentistry, we are

false men, and will set 'false teeth,' and never realize our high destiny."

Grinding and Adjusting Single Gum Teeth.—In *arranging* or adjusting single gum teeth to the plate in those cases where the changes in the form of the alveolar ridge, consequent on absorption, are completed, the portions applied to the base should be ground away sufficiently to restore the required fulness of the parts and to give proper length and inclination to the teeth. The coaptation of the ground surfaces to the base should be accurate enough to exclude perfectly particles of food, and to furnish such a basis to each tooth as will provide most effectually against fracture when acted upon by the forces applied to them in the mouth. The gum extremities of the teeth should also be accurately united to each other laterally by grinding carefully from their proximate edges until the joints or seams will be rendered incapable of ready detection in the mouth, care being taken that this coaptation of the adjoining surfaces is uniform, for if confined to the outer edge alone, portions of the gum enamel may be broken away in the process of soldering.

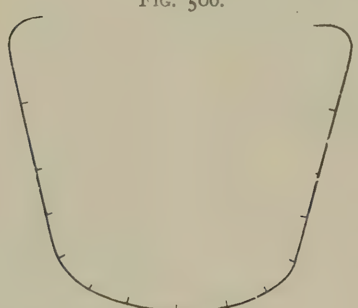
Arranging for Temporary Plates.—In the construction of substitutes designed to fulfil only a temporary purpose, and where the alveolar processes remain in a great measure unabsorbed, and plain teeth (those representing but the crowns of the natural organs) are used, but little skill will ordinarily be required in adjusting and fitting them to the base. If the ridge in front is prominent and but inadequately concealed by the lip, as where the teeth have been but recently extracted, all those portions of the border of the plate in front, anterior to the first or second bicuspid on each side, may be cut away on a line a little within the required circle of the anterior teeth and scalloped, permitting the anterior cervical portions of the artificial incisors and canines, and, in some cases, the anterior bicuspids, to overlap the edge of the plate and rest directly and firmly upon the gum in front. This abridgment of the plate will not ordinarily, materially affect the adhesion or stability of the substitute.

There are cases of a mixed character that render it more difficult to effect a harmonious and symmetrical arrangement of the

teeth, as where a limited number of the natural teeth at intervals have been long absent, and the excavations in the ridge consequent on absorption alternate with other points upon the ridge in a comparatively unchanged condition. To give uniformity to the denture by restoring perfectly the required circle of the arch in such cases will necessitate the employment of plain and single gum teeth conjointly. Whenever necessary, those portions of the base occupied by the plate teeth may be cut away in such a manner as to permit the latter to be adjusted directly to the unabsorbed gum as before described.

Arranging the Teeth for a Full Upper and Lower Denture.—In the process of grinding the teeth to the base, above and below, the operator should commence by first arranging the superior central incisors, and then the lower, and so, passing back from tooth to tooth, grind and adjust an upper and lower tooth alternately, keeping the upper ones in advance of those of the lower jaw. The central incisors above should be placed parallel with each other, but the cutting edges of the laterals and the points of the canines should incline slightly toward the median line of the mouth. In arranging the teeth of the upper jaw, the anterior six may be made to describe, with more or less exactness, the segment of a circle, but a somewhat abrupt angle may be given to the arch on each side by placing the first bicuspid within the circle in such a way that, when standing directly in front of the patient and looking into the mouth, only a narrow line of the exterior face of the crowns of these teeth will be seen, while the remaining teeth posterior to them should be arranged nearly on a straight line, diverging as they pass backward. When arranged in the manner described, the peripheral outline of the arch will exhibit somewhat the form presented in the diagram (Fig. 506).

Fig. 506.



In regard to the practical efficiency of an upper denture re-

tained in the mouth by atmospheric pressure or adhesion, it is important that the teeth engaged in the comminution of food, as the bicuspids and molars, should occupy a position directly over the central line of the ridge, and should either be arranged vertically or with a slight inclination toward the center of the mouth. The liability to displacement of the substitute in mastication will thus be greatly diminished, whereas, if placed outside of the line indicated, and especially with a diverging inclination, the stability of the appliance will be endangered and the functions of mastication impeded, notwithstanding other conditions necessary to complete success have been fully secured. In arranging the upper and posterior teeth as described, it will sometimes be necessary to give to the opposing under teeth a decided inward inclination in order to effect a satisfactory antagonism of the teeth; and cases occur where a practical articulation cannot be secured without departing in some degree from the arrangement of the upper teeth spoken of,—as where a great disparity exists between the posterior transverse diameters of the two jaws, a medium-sized, or even small, arch above being associated with an expanded ridge below.

In articulating the upper and lower teeth, the normal occlusion of the natural organs should be imitated as nearly as the other essential requirements of the case will admit. Hence the upper front teeth, describing the segment of a larger circle than the corresponding teeth of the lower jaw, will project beyond and overlap slightly the cutting edges of the latter; and having a greater width of crown, they will extend laterally beyond the opposing teeth, covering one-third of the crowns of those next adjoining, so that when the canines of the upper jaw are reached they will close between the lower canines and first bicuspids; and, passing back, the anterior superior bicuspids between the first and second bicuspids below; the posterior bicuspids above, between the second inferior bicuspids and anterior molars; the first superior molars between the first and second molars below; while the anterior half of the posterior molars above will close upon the posterior half of the inferior second molars, the remaining posterior half of the second molars above extending posteriorly beyond those of the lower

jaw. The outer cusps of the superior bicuspids and molars will overlap those of the inferior teeth; while the inner cusps of the teeth of the superior jaw will pass into the depressions in the lower teeth formed by the internal and external cusps, and the external cusps of the inferior teeth will, in like manner, be received into the corresponding excavations of the upper teeth. An abnormal relation of the jaws, as where undue projection, absolutely or relatively, of either maxilla exists, or where the lower jaw closes on one side or other of the upper, will frequently compel a departure from the ordinary arrangement of the artificial organs, the extent of which must be determined by the necessities of each individual case.

In selecting teeth for a full upper denture in those cases where natural teeth are remaining below, or *vice versâ*, the color, size, and form of the latter will serve as a guide in the choice of teeth appropriate for the opposite jaw. In fitting and arranging the teeth upon the base, and in antagonizing them with the opposing natural teeth, the same general principles apply as those already adverted to in connection with full upper and lower dentures.

Having adjusted the teeth to the base, they should be placed in the mouth before uniting them permanently to the plate, to detect and remedy any error of arrangement either in respect to prominence, position, inclination, length, or antagonism.

Forming a Rim to the Plate.—If the case is one where single gum or block teeth are employed, and it is intended to form a socket or groove upon the borders of the plate for the reception of the plate extremities of the teeth, the rim forming the groove should be fitted and soldered to the base before investing the piece in plaster. *If the alveolar ridge above is shallow, and but imperfectly concealed by the lip, a rim to the plate will be inadmissible*, as, when the mouth is opened and the lip retracted, as in laughing, the metallic band will be exposed to view. A rim may be fitted and attached to the base in either of the following ways:—

1. A strip of plate from one to two lines in width is adjusted to the plate, with one edge resting on the uncovered border of the plate close to the gum extremities of the teeth, and the other

overlapping and embracing the latter. The rim may be more conveniently adjusted by employing two pieces, extending from each heel of the plate and uniting in front.

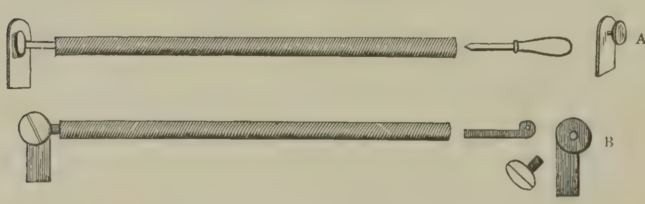
2. A half-round wire with the edge beveled where it joins the ends of the teeth, forming a narrow groove, may, in like manner, be fitted to the plate, furnishing a shallow bed for the gum extremities of the teeth. A narrow strip of plate, about the thickness of heavy clasp material, may be substituted for the half-round wire. In either case, the better plan is first to trace the outlines of the gum portions of the teeth upon the plate with a sharp instrument; remove the wax and teeth from the plate; draw another line a little within the first all round, and solder the rim to the line last drawn; remove the teeth from the wax, and readjust the latter in its proper place upon the plate; then fit each tooth separately to the rim by grinding away sufficiently from the end of the tooth to effect an accurate adjustment of it to the socket. The ends of the teeth may be ground away to the rim until the platinum pins freely re-enter the rivet-holes in the wax, thus restoring them to their proper position in relation to the base.

3. Another method of forming a rim, and probably the best, consists in swaging a strip of plate accurately to the form of the parts to which it is applied. An impression in wax or plaster is first taken of the gum surfaces of the teeth and exposed border of the plate; but as it will be impossible to detach either wax or plaster in perfect condition when encircling the entire arch, or to swage perfectly with a die so unfavorably formed for stamping, separate impressions of the two lateral halves of the piece should be taken from these plaster models, and from the latter, dies and counters;—with these, two strips of plate of sufficient width are swaged, each extending from the heel of the plate to a little beyond the median line in front, overlapping slightly at the latter point. The portions of the swaged strips embracing the plate ends of the teeth are then trimmed to the proper width, and scalloped, if desired, in correspondence with the festoons of the artificial gums. In whatever way the rim is formed, when it has been fitted to the plate and teeth it may be held temporarily in place with clamps adjusted at two or three

points around the plate and then transferred to a piece of charcoal, and secured by first tacking it at two or three points with solder. The groove may then be filled with whiting, mixed with water or alcohol, to prevent the solder from flowing in and filling it up; after which small pieces of solder are placed along the line of union next the edge of the plate, and the rim permanently united throughout with the blowpipe; after which the wax and teeth are reapplied to the plate.

Constructing and Attaching Spiral Springs.—The success which has been attained in the use of atmospheric pressure and adhesive plates has almost entirely superseded the necessity of employing spiral springs as means of support; nor should the latter be resorted to except under circumstances that preclude the use of the former, as in case of cleft palate, for instance.

FIG. 507.



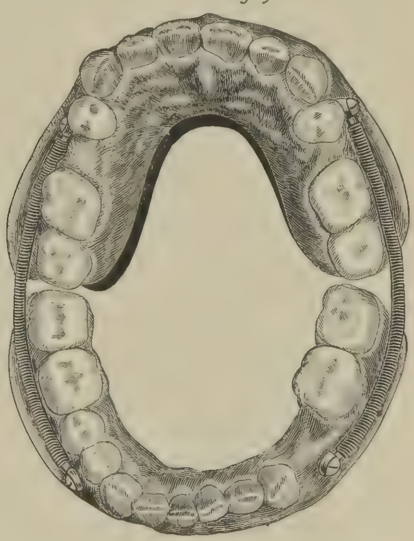
When applied, they should be attached to the base on each side between the posterior bicuspid and first molar below, and opposite the posterior bicuspid above. To the border of the plate near the base of the teeth a narrow strip of plate is soldered, extending up and lying closely against the side of the latter, to the end of which, near the grinding surfaces of the teeth, is adjusted a small, circular cap of gold connected with the standard by a small wire on which the looped extremity of the spring plays. To each end of the spring is attached a gold wire, doubled upon itself in such a way as to form a loop, the closed ends being soldered together and filed to enter the hollow in the wire, A, Fig. 507. B, Fig. 507, copied from Professor Harris's work on dental surgery, represents another method of attaching springs, but the former is more readily constructed and will answer every

practical purpose. Figs. 508 and 509 exhibit the application of springs to an upper and lower denture. In this instance plain teeth are shown, but they may be readily attached to either plain or gum teeth.

Investing.—The plate, with the wax and teeth in place, is next encased in a mixture of plaster preparatory to backing the teeth and uniting them with solder to the base. For this purpose, plaster and sand may be employed, using as little of the former as will serve to hold the investment together during the subsequent manipulations. Asbestos may be added, and is a useful ingredient

FIG. 508.

FIG. 509.



Burnt plaster, or that which has been previously used for investing, may be substituted for the sand and asbestos, adding a sufficient quantity of unused plaster to effect consolidation. Either of the combinations mentioned will suffer but little change in the fire if properly managed. It is customary to incase the piece in the plaster mixture to the depth of from one-half to three-fourths of an inch, leaving only the lingual surfaces of the plate and teeth uncovered.

Warping or Springing.—However comparatively free from

change of form the best combinations of plaster may be, yet some slight contraction of the body of the investment doubtless ensues on the application of heat, and it is probable that so large and resistant a mass must tend, in some degree, to produce deformity of the plate in soldering; for, as the investment contracts and the plate at the same time expands when heated, a change in the form of the latter must occur whenever the force exerted by the shrinking plaster exceeds the expansive force of the metal; and when the peculiar form of the upper plate is considered we can readily conceive how a slight contraction of the plaster of the thickness mentioned may "warp" or "spring" the plate when its uniform linear expansion and contraction is so effectively opposed. The change in the form of the base from this cause will, according to the writer's observations, be found, in an upper plate, to exist on each side of the sloping walls of the palate, embracing the posterior half or two-thirds of the plate at these two points—the change manifesting itself in an inward displacement of the lateral walls of the plate midway between the summit of the palatal arch and the most depending portion of the ridge. We would suggest in explanation of this result that, as the plaster contracts with sufficient force to carry the plate with it, the sides of the latter are approximated, while the palatal portion is at the same time lifted up. Now it seems plain that inasmuch as the portions of plate overlapping the ridge are encased in and embraced by the plaster, and as the palatal portion is arched in form with its convexity presenting to the plaster, and therefore self-sustaining in respect to its own peculiar form, the special configuration of these parts cannot suffer any appreciable change; but as they are forced toward the common center of the mass, their *relation* to each other is also changed, and this changed relation must necessarily result in a deformity of those parts of the plate which offer the least resistance to the contractile force of the plaster. In obedience to this necessity, the sides of the plate along the sloping walls of the palate, which from their form are neither resistant nor self-sustaining under pressure, and whose inward displacement is unopposed by any counter force, are projected in toward the center of the palatal excavation in proportion as the borders

and central portions are approximated or converged in the direction of the center of the piece. The practical effect of this approximation of the lateral and posterior borders and internal displacement of the plate is to make the latter "bind" upon the outer and posterior borders of the alveolar ridge, and to throw the central portion of the plate from the roof of the mouth.

Methods of Overcoming the Tendency to Change in Form.—To obviate, as far as practicable, any change in the form of the plate which may result from the contraction of the plaster investment, various expedients have been suggested, but the following will sufficiently counteract the influence of the plaster by permitting an unobstructed expansion and contraction of the metallic base. Take a band of tolerably thick copper plate as wide as the plate and teeth are deep; bend it to the form of the plate, but large enough to leave a space of nearly half an inch between it and the teeth, the ends being united to each other back of the plate by riveting or otherwise. Holes are then made in the band at numerous points throughout its extent, through which wire is introduced and interlaced on the inside in such a way as to form loops, the latter extending in to within a short distance of the teeth. The plaster is then filled into the space between the band and teeth, even with the cutting and grinding surfaces of the latter; the palatal surface of the plate is also covered with plaster and may be connected with the outer portion by a very thin layer at the edge of the plate, or the two may be entirely disconnected. The expansion of copper being very nearly that of gold, the body of the plaster, when heat is applied, will be carried in advance of the borders of the plate as the latter expands, while the thin portion of plaster at the edges of the plate will allow the central portion of the latter to expand with but little or no interruption. On cooling, the entire mass will contract and assume its original form, unless warping is induced by other agencies acting independently of the enveloping plaster, as excess or unequal distribution of solder, irregular heating, etc.

It is not, ordinarily, necessary to provide by any special expedient against warping of the lower plate, as any slight change of

form consequent on contraction will not materially affect its adaptation to the lower jaw,—its only effect being to impart to the substitute a slight lateral play upon the ridge. The plaster on the inside of the lower piece may be cut away to the edge of the plate, while that external to the teeth should not be added in greater quantities than is barely sufficient to hold the latter in place whilst lining and soldering them to the base.

Backing or Lining the Teeth.—The plate being properly invested, all portions of the wax attached to the inner surface of the teeth and plate should be thoroughly removed with suitable instruments, after which stays or backings are to be adjusted to the teeth. In reference to the method of forming and adjusting stays, little need be added to what has already been said when treating of partial dentures. One method, not there specified, consists in first fitting to each tooth separately, in the usual manner, a thin stay formed of platinum, which is temporarily fastened to the tooth by splitting and spreading apart the ends of the rivets with a small chisel-shaped instrument. The teeth are then removed from the investment and partially embedded side by side in plaster, the platinum strips remaining uncovered. The plaster and teeth may then be raised to a full red heat with a blowpipe or by placing them in the furnace. Small pieces of gold plate, of equal fineness with the base, are then placed upon the surfaces of the platinum stays and thoroughly fused with the blowpipe until they flow perfectly in around the rivets, and uniformly over the surface of the linings. If sufficient heat is applied, the solder will insinuate itself between the stay and tooth, and thus render the coaptation of the two perfect. Small pieces of gold plate should be added until sufficient thickness is imparted to the linings. The backings are then trimmed smoothly and burnished, when they may be placed back in the investment in their appropriate places. The linings which support the teeth may be united to each other laterally in sections or continuously. When the teeth are joined to each other throughout, a very small quantity of solder will be sufficient to support the teeth, provided it is well diffused along the joints, uniting them perfectly at all points.

Soldering and Finishing.—The process of preparatory heating, soldering, pickling, and finishing the plate is the same in all respects as that described when treating of partial pieces, and need not, therefore, be recapitulated.

In the final adjustment of the finished piece to the mouth, and after any additional grinding of the masticating surfaces of the teeth necessary to perfect the antagonism has been performed, such instructions should be given to the patient in regard to the care and management of the appliances as will best promote their immediate and successful use. The wearer should be impressed with the absolute necessity of early and prompt attention to any injuries inflicted upon the soft tissues of the mouth by the substitutes, as much future trouble and annoyance, if not permanent mutilation of the parts, may result from neglect, but which may be readily averted, in most instances, by a timely removal of the sources of injury. To obviate, in some measure, the tendency to displacement of the base, which usually accompanies the first use of artificial teeth, and especially the upper denture, the patient may be directed, when dividing food with the front teeth, to press the substance backward and upward against the cutting edges of the superior incisors at the same time that the opposing teeth are closed upon each other, thus dividing completely the substance seized. In reference to the mastication of food, it has been suggested to instruct the patient to distribute, by the action of the tongue, the portions of food as equally as possible on each side of the mouth, in this manner distributing the forces applied, and thereby lessening the chances of lateral displacement of the substitute.

CHAPTER XI.

MANUFACTURE OF PORCELAIN TEETH.

The perfection and completeness of results attained at this day in the production of porcelain teeth, approximating so nearly the natural organs in all their more obvious, physical, and distinctive characteristics as to be almost, if not quite, indistinguishable from the latter when applied in obedience to the esthetic requirements of individual cases, is one of the marvels of ceramic art. Nowhere, perhaps, have the conceptions of genius been embodied in porcelain with more truthfulness or greater fidelity to nature than in the exquisite and wonderful imitations of the dental manufacturing laboratory.

So amply and satisfactorily has the intelligent, progressive, and well-directed enterprise of manufacturers provided for all the ordinary needs of prosthetic practice in the almost endless variety in size, color, configuration, relation, and adaptability of single and sectional teeth, that the work of hand-carving is now rarely demanded of the general practitioner except in extreme cases resulting either from accident or disease. Thus, as aptly remarked by the late Professor Austen: "The dental depot not only renders service by the superior excellence of the surgical instruments and prosthetic materials which it supplies, but it directly benefits the science and art of dentistry by releasing the practitioner from manufacturing toil, and giving time for the acquirement of increased knowledge and skill. Thus, if the time heretofore given to block-making were devoted to the study of dental esthetics, patients would have the benefit of an artistic selection from a far larger variety of porcelain dentures than could otherwise possibly be made."

As affording some curious as well as practical information in regard to the composition and manufacture of porcelain teeth, the following descriptions will be found of interest:—

Components of Dental Porcelain.—Manufactured single and sectional mineral teeth, carved block-teeth, continuous-gum material, etc., are composed of two distinct portions,—the *body*, or *base*, and *enamel*. The chief mineral substances which compose the body are *silex*, *felspar*, and *kaolin*. The enamel, both crown and gum, consists principally of *felspar*.

The various tints or shades are imparted to the porcelain by certain metals in a state of minute division or their oxids. The more general properties of the mineral ingredients will be first described.

Silex.—Silex, silica, or silicic acid, is a white powder, inodorous, and insipid. It forms the chief part of many familiar mineral formations, as quartz, rock-crystal, flint, agate, and most sands and sandstones, in some of which it occurs nearly pure. Silica, in its pure state, is insoluble in water or acids, and is infusible in the highest heat of the furnace; it melts, however, in the flame of the oxyhydrogen blowpipe, passing into a transparent, colorless glass. Its specific gravity is 2.66; and it is composed of silicon, 48.04, and oxygen, 51.96. Only the purest varieties of silex are employed in the manufacture of porcelain teeth. It is prepared for use by subjecting it to a white heat and then plunging it into cold water, after which it is ground to a very fine powder in a mortar.

Felspar.—This mineral substance occurs crystallized in oblique rhomboidal prisms, and is a constant ingredient of granite, trachyte, porphyry, and many of the volcanic rocks. The felspathic mineral formations present either a pearly or vitreous luster, and vary in color, being red, green, gray, yellow, brown, flesh-colored, pure white, milky, transparent, or translucent. Felspar yields no water when calcined; melts at the blowpipe into a white enamel, and is unaffected by acids. It is composed, according to Rose, of silica, 66.75; alumina, 17.50; potash, 12; lime, 125; oxid of iron, 0.75. It is found in various localities throughout the United States, the purest and whitest kinds being employed in the manufacture of mineral teeth. It is prepared for use in the same manner as silex.

Felspar, from its ready fusibility, serves to agglutinate the

particles of the more refractory ingredients, silex and kaolin; and when diffused throughout the mass imparts to the porcelain a semi-translucent appearance.

Kaolin.—Kaolin, or *decomposed felspar*, is a fine white variety of clay, and is composed chiefly of silica and alumina, the latter being the characteristic ingredient of common clay. It is found in various localities throughout the Eastern States and in parts of Asia and Europe. Kaolin is refractory, or fire-proof, but is rendered more or less fusible by the contaminations of iron and lime with which it is usually combined. The opaque and lifeless appearance characteristic of the earlier manufacture of mineral teeth was due to the introduction of a relatively large proportion of this clay into the body of the porcelain. The peculiar translucent and lifelike expression which distinguishes the beautiful imitations of the present day is due, in great part, to the comparatively small proportion of kaolin clay, and an increased amount of the more fusible and vitreous component, felspar.

Kaolin is prepared for use by washing it in clean water; the coarser particles having settled to the bottom, the water holding the finer ones in solution is poured off, and when the suspended clay is deposited at the bottom of the vessel, the water is again poured off, and the remaining kaolin dried in the sun.

Coloring Materials.—The following metals and oxids are employed in coloring mineral teeth: titanium, platina sponge, and oxid of gold being those chiefly used in producing the more positive tints, and by combining which, in varying proportions, any desired shade or color may be obtained.

METALS AND OXIDS.	COLORS PRODUCED.
Gold in a state of minute division,	Rose red.
Oxid of gold,	Bright rose red.
Platina sponge and fillings,	Grayish-blue.
Oxid of titanium,	Bright yellow.
Purple of Cassius,	Rose purple.
Oxid of uranium,	Greenish-yellow.
Oxid of manganese,	Purple.
Oxid of cobalt,	Bright blue.
Oxid of silver,	Lemon yellow.
Oxid of zinc,	Lemon yellow.

As the preparation of most of the above colors requires great care and a somewhat intimate knowledge of chemistry, and as the most delicate manipulations are necessary to secure accurate and satisfactory results, it is better for the mechanical operator to procure the coloring ingredients already prepared from some competent chemist, rather than attempt their production himself. For a particular description of the various modes of preparing them, the reader is referred to Piggot's *Dental Chemistry and Metallurgy*, and other works treating fully of the subject.

Manufacture of Porcelain Teeth.—The subjoined account of the processes concerned in the manufacture of porcelain teeth is descriptive of those at present employed by most of our leading manufacturers.

The felspar is first *calcined* by throwing it in large masses into a furnace, and subjecting it to a red heat and then plunging it into water, which renders it brittle and easily broken by the hammer into small pieces, so that all foreign matters, such as mica or iron, with which it may be mixed, can be separated. It is then crushed between flint stones, and when fine enough is afterward ground under water in a mill in which heavy blocks of French bur-stone revolve upon a nether millstone of the same material, until sufficiently pulverized, when it is floated off and allowed to settle. After this the water is drawn off or evaporated, and the deposit of spar dried and sifted.

The silex is subjected to the same treatment.

The kaolin, already of the desired consistency as found in nature, is prepared for use by first washing out impurities, and then drying.

The mineral ingredients are ground somewhat coarsely, but the coloring materials are reduced to an impalpable powder by means of a mortar and pestle machine of great power.

When properly prepared, the several materials are combined in suitable proportions to form the body and enamels, and are then mixed with water and worked into masses of the required consistency for molding. The degree of plasticity of the body and enamel pastes differs with the methods of manufacture. Formerly, the teeth, when molded, were first exposed to a heat just sufficient to produce partial baking of the body, and this was

called cruising or *biscuiting*, after which a thin paste of enamel material was applied with a camel's-hair brush, and the whole subjected to a second heat for complete and final fusion. This preliminary process of biscuiting is essential in carved block and continuous-gum work, but in most of the factories this partial baking is dispensed with, and the body and enamel pastes of the uniform consistency of putty are introduced into the molds, in the first instance, properly distributed, and final fusion effected by a single exposure to heat.

The molds are made of brass and are in two sections, one-half of the tooth being represented on either side. The exact form of the tooth is carved out with great care and precision, and must be anatomically correct and mechanically perfect, while the matrix is made about one-fifth larger than the required size to compensate for shrinkage of the materials in baking. Holes are drilled in each half of the mold to receive the platinum pins, and the exact closure of the two pieces of the mold secured by guiding pins.

The molds having been previously oiled, and the platinum pins, which vary in length and thickness to meet special requirements, placed with small tweezers in the holes provided for them, the crown and gum enamels are first carefully laid in with small steel spatulas in the required quantity and position. The body is then added, in quantity exceeding somewhat the capacity of the mold, when the sections of the mold are closed upon each other and subjected to a pressure sufficient to insure compactness of the enclosed mass. When thoroughly dried by a slow heat, to which the molds are exposed, the teeth are readily disengaged when the matrix is separated, and will be found at this stage extremely friable and tender, requiring great care in handling them.

They are then sent from the molding to the trimmer's room, where, after critical inspection, all defective ones are either repaired or condemned, all excess of material cut smoothly away, and the arch of the gum over each tooth made true and smooth with fine, pointed instruments. They are then placed on beds of coarse quartz sand, on fire-clay trays or slides ready for the furnace.

Referring to this stage in the process of manufacture, an intelligent observer writes :—

" Beyond this no tool can follow them. Imperfections heretofore could be repaired, but in the future, beyond the fire, the tooth is either perfect or a failure irremediable. The furnace is an institution entitled to respect for its intensity. In its center is a muffle of fire-clay, entirely surrounded by the glowing fuel, a charge of half a ton's weight of coal, itself carefully bricked up before firing, that no impurities of dust or vapor shall reach the teeth. Take out the small, half-oval door of the muffle and you will see an inner glow the eye shrinks from registering, an incandescence that startles you by its fervor. In from fifteen to thirty minutes, teeth and fire-clay slide, glowing like the oven, are taken out finished. The dull enamel has become as glass. The lusterless oxids have yielded their color, and the tooth that went in friable and brittle has come out adamant. But there is an intermediate skill, the acquisition of which is one of the marvels of the mechanic arts. A little too long in that heat and the teeth are ruined, and the evils of '*underdone*' are equally to be guarded against. It is a trained judgment, a skill of eye and handling that enables the burner to lend success to the work of those who have gone before him, and at the precise point where a shade of failure is utter ruin."

The teeth are now done and ready for the wax cards, on which they go to the trade.

CHAPTER XII.

UNITING SINGLE PORCELAIN TEETH TO EACH OTHER AND TO A METALLIC BASE WITH A FUSIBLE SILICIOUS COMPOUND, FORMING A CONTINUOUS ARTIFICIAL GUM.*

("CONTINUOUS-GUM WORK.")

The process of uniting single mineral teeth to each other and to a metallic base by means of a porcelain cement was attempted as early as 1820, by Delabarre, of Paris, France, but with such imperfect and unsatisfactory results as induced its early abandonment. At a later period, Dr. John Allen, a distinguished practitioner of dentistry in America, devised a method embracing original and important modifications of practice both in the preparation and combination of materials, and the modes of manipulating them; and after an extended series of experiments, commencing in 1844, succeeded in obtaining certain mineral compounds which vitrified at a heat much below that employed by Delabarre, and the contraction of which corresponded so nearly with that of the platinum base to which it was applied that the shrinkage incident to baking conflicted in no material degree with the practical utility of the work in the mouth.

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* The attentive reader of the first edition of this work will not fail to note that the statements involving the question of *priority*, contained in the introductory portion of the above chapter, are at variance with those originally published. A more extended examination and careful analysis of the evidences as they appear upon record—evidences not fully accessible to the author at the time of the publication of the first edition—established beyond reasonable doubt the just claims of Dr. Allen as the originator of that special and distinctive method here considered, by which the attachment of the teeth to the plate is effected by direct fusion of the gum material. Dr. Hunter's earliest and contemporaneous experiments contemplated simply a union of all the teeth by means of a fusible cement, forming a single, continuous block, which was afterward united to the base by riveting or soldering.

This brief explanation is here introduced as an act of simple justice to the late Dr. Allen, who devoted the best energies of his life to the successful development of a process which stands unrivaled in all the chief requisites of an artificial denture.

In the construction of dentures upon this principle, plain single teeth, made for the purpose, are arranged and soldered to a plate properly fitted to the mouth, after which different mineral compounds, made to represent the natural gum tissues, etc., are applied to the plate and teeth in a plastic state, then carved and trimmed in proper form, and by means of a strong furnace heat these compounds, called the body and the gum enamel, are fused, producing a continuous and seamless artificial gum and palate indistinguishable from the natural structures.

The compounds at present employed in this process, as well as the more fusible preparations used for repairing purposes, are manufactured in quantities sufficient to meet the wants of the profession, and may be procured at all the dental furnishing houses throughout the United States.

The intimate but later identification of Dr. W. M. Hunter with the above process has rendered his name familiar as one whose skill and devotion to this specialty of mechanical practice has contributed to its development in a modified form. Dr. Hunter's formulas and modes of manipulating his compounds will be introduced hereafter.

Following Dr. Hunter's descriptions, the reader will find practical and valuable instructions in this method of substitution, contributed, at the solicitation of the author, by Dr. S. P. Haskell, of Chicago, Ill., Professor George S. Field, of Detroit, Mich., and Dr. Ambler Tees, of Philadelphia, Pa., whose long experience and intimate familiarity with the most approved methods of constructing continuous-gum dentures impart special value to the subject-matter of their communications.

Before introducing an account of Dr. Allen's modes of procedure, we would premise that it is unnecessary to repeat in this connection what has already been fully described in regard to impressions of the mouth, or the manipulations connected with the formation of plaster models and metallic swages, these processes being essentially the same as in the construction of ordinary gold work.

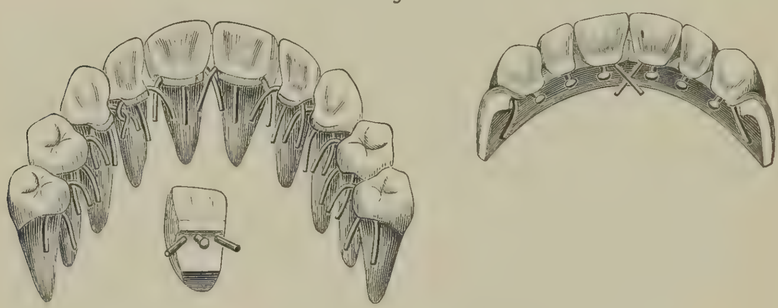
Dr. C. H. Land, of Detroit, Michigan, has devised an ingenious method of attachment.

The improvement, in its application to continuous-gum work,

is in the construction of the teeth, which are provided with three pins arranged transversely in the cervical portion of the tooth,—one in the center, and one upon either side on the posterior lateral aspect of the cervix, the latter being somewhat longer than the center pin. The long pins at the sides are so arranged that, when the teeth are in position, the lateral pins of all the teeth will cross each other, as shown in Fig. 510. The pins so crossed, and also the center pins, are pressed down closely upon the plate, and the whole united to each other and to the base by flowing solder at the points where they cross, and at their line of junction with the base.

These teeth are designed more especially for continuous-gum work, but are applicable to dentures attached to gold plates by

FIG. 510.



rubber or celluloid, and may be used also to advantage, in a modified form, in the use of rubber or celluloid alone.

The particular advantages claimed for these teeth are, that in their use in continuous-gum cases, equal or greater strength is imparted to a plate made much thinner than those ordinarily employed, say 32 to 33 Stub's gauge, thus materially reducing the weight of the piece, while at the same time they offer greater facility and certainty in the manipulation of the gum body.

It may also be premised, before considering individual methods, that it has not been deemed necessary to encumber a description of these processes by illustrations of the different kinds of furnaces used for the purpose. These have been fully represented under the head of "Furnaces."

Dr. Allen's Methods.—The following descriptions embrace the methods and manipulations practised by the late Dr. John Allen in the construction of artificial dentures with continuous gums.

The plate or base is formed of platinum, or platinum and iridium. The plate being properly fitted to the mouth, and wax placed upon it for the bite, as in ordinary plate work, the teeth are arranged thereon with special reference to the requirements of the case. They are then covered with a thin coating of plaster mixed with water to the consistency of cream. After this has become firmly set, another mixture of plaster and asbestos with water, somewhat thicker or more plastic than the first, is placed round on the outside of the previous covering and the plate. A convenient way of applying the second covering is to turn the mixture out of the vessel upon a piece of tin, say four or five inches square, thus forming a cone, upon which the plate, with the teeth upward, is pressed gently down until within an inch or less from the tin. Then with a spatula the mixture is brought up over the teeth, forming an investment that will not crack in the process of soldering. Sand may be used with the plaster for this purpose, but I think asbestos preferable.

Attaching the Teeth.—When the covering has become sufficiently hard, the wax is removed, and a rim of platinum is then fitted to the lingual side of the teeth, below the pins, and to the base-plate. The pins in the teeth are then bent down upon the rim, and soldered with pure gold, or a mixture of gold and platinum, at the same time the rim is soldered to the plate. This rim, which forms the lining for the teeth, is usually about the thickness of the plate upon which they are set, say twenty-eight to thirty; but should the case require more than ordinary strength, a double or triple thickness of rim should be used. This may become necessary in cases where the natural molar teeth are standing firmly in the opposite jaw, and antagonize with the artificial piece, or where from any cause an undue strain is brought to bear upon the artificial teeth. To attain successful results, the dentist must take into consideration all the circumstances or conditions of each particular case, and then exercise his best judgment in executing the work.

In soldering platinum with pure gold, flat surfaces of this metal should be brought in positive contact, in order to become firmly united. Therefore in mounting teeth upon a plate of this kind the backing or inside rim should be a little wider than the distance between the pins in the teeth and the plate, say from an eighth to a fourth of an inch. This extra width of rim should be bent at right angles along the base of the teeth, so as to admit of being pressed down upon the plate after the rim is adjusted to the teeth, and the pins bent down firmly upon it. In this way flat surfaces of the rim and plate are brought together and soldered. The pins in the teeth are also soldered to the rim at the same time. When the parts are thus united, they will remain so during the subsequent bakings; but if the edge of the rim only is fitted to the plate and soldered like gold or silver work, the subsequent heatings for baking the body and gum will cause the gold to become absorbed in the platinum, and leave the joints not united. It may be asked, Why not use common gold solder for this style of work? Answer, because the alloy in the solder will greatly injure the color of the gum enamel in baking. Copper alloy will turn it to a greenish shade, and silver will give it a yellow tinge. Although pure gold requires more intense heat to melt it (being about two thousand degrees) than ordinary gold solder, yet when melted it flows much more freely than the latter. The best way to solder the teeth upon platinum plate is to place small pieces of gold upon the joints or parts to be soldered, with wet ground borax, and then slowly introduce the piece with the investment into a heated muffle, and bring the whole mass up to a red heat; then withdraw it from the furnace, and bring it quickly under the blowpipe to flow the gold. In this way the teeth do not become etched, as they are liable to be if the soldering is done in the furnace.

The piece being soldered and cooled, the covering is removed from the teeth, taking care to preserve the base unbroken for the plate to sit upon during the subsequent bakings of the body and gum enamel.

Preparing and Applying the Body.—All particles of plaster or other foreign matter should be removed from the teeth

and plate by thoroughly washing and brushing them. It is well to immerse the piece for a short time in sulphuric acid, after which rinse and brush it well with water. This done, a colorless mineral compound, called the body, is applied in a plastic state (with spatulas or small instruments for the purpose) to the teeth and plate. It is then carved to represent the gum, roof, and rugæ of the mouth, taking care to keep the crowns of the teeth well defined. Small, clean cuts with a thin knife blade should then be made, one between each of the teeth. Commencing with the space between the molars, the cuts should be made externally and internally entirely through the body to the stay and the plate. The object of these separations is to

FIG. 511.

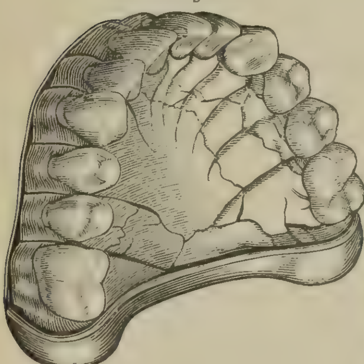
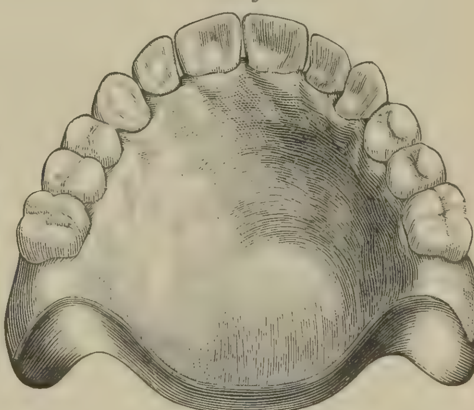


FIG. 512.



prevent movement on the part of the teeth from contraction of the body in baking, compelling the material to shrink toward the teeth and unite with them, leaving smooth and irregular openings where the incisions were made, into which more material is readily introduced and baked. Fig. 511 shows a case after the first heating.

First Baking.—The piece is then placed on the base upon which it was soldered, and set upon a slide on the apron in front of one of the upper muffles of the heated furnace,—and every eight or ten minutes it should be moved forward into the muffle, say two or three inches each time, until the piece shall

have passed the center of the same, which should be at a red heat. It is then withdrawn and passed into a lower muffle, where the heat is greater, in which the body soon becomes semi-vitrified, which is sufficient for the first bake. It is then taken out and (together with the slide on which it was baked) placed in a cooling muffle, the mouth of which should be closed to prevent the change of temperature from being too rapid and causing the teeth to become brittle. When the piece is sufficiently cool to handle, a second application of body is made for the purpose of repairing any defects that may have occurred in the baking; this done, the piece is again introduced as before into the upper muffle, then in the lower, allowing the second bake to become a little harder than the first, but not so much as to appear glossy. It is then withdrawn, and cooled as described above.

Applying the Gum Enamel.—A flesh-colored compound is then applied, which is called the gum enamel. This is also made plastic with water, and a thin coating is put over the body and closely packed and carved around the teeth with small instruments made for the purpose,—still taking care to keep the crowns of the teeth clean and well defined. Small camel's-hair brushes are used wet with water to cause the gum enamel, and also the body, to settle more closely around the necks of the teeth; other brushes are also used dry to remove all particles of body, gum, or other substances from the crowns of the teeth.

Final Baking.—After the application of the gum enamel, the piece is again subjected to the heat of the furnace as described for baking the body, with this difference: The heat should be a little greater than for either of the preceding bakes. It should be a strong, sharp heat, in order to produce a smooth, glossy appearance, which is required for the enamel. These different degrees of heat for the first, second, and third baking should be carefully observed for the purpose of getting an even temper in the piece, and thereby preventing it from crazing or cracking in cooling.

The enamel being thoroughly fused, the piece is withdrawn from the heated muffle, and passed into another, outside of the furnace. This muffle should be made quite hot before the

denture is placed in it, in order to prolong the cooling process; for if the piece is cooled too rapidly it is rendered more fragile. It is well to let the case remain in the cooling muffle, with the mouth of it closed, several hours before exposing it to the air. By baking just at night the piece will be in proper condition to finish up the next morning. Fig. 512 shows the case completed.

The Finishing Process consists simply in smoothing and polishing the plate and burnishing the rim. It is then ready to be adjusted to the mouth. In baking great care is necessary to prevent the piece from becoming gassed. This can be avoided by allowing the gas to escape entirely from the burning coal or coke in the furnace before the piece is introduced into the muffle. The presence of gas is indicated by the blue flame escaping from the coal. When the fire becomes clear, it is then safe to introduce the case to be baked (as before described) into the muffle. Pure anthracite coal is the best for this purpose, as it maintains a longer and stronger heat than coke. Bituminous coal is not good for this kind of work unless first converted into coke.

It often occurs that the natural gums will change more or less after the teeth are inserted. In such cases a new impression should be taken from the mouth and a fusible die formed. The denture is then placed upon the die, and it will be seen at once where the change has taken place; then with the piece resting upon the die the artificial gum may be chipped off with a small hammer and chisel. The platinum plate, being soft, can be refitted to the die very accurately with a burnisher, hammer, and small driver made for the purpose. A new coat of body is then applied where the plate has been refitted, and then baked, cooled, enameled, and baked again,—still observing the same directions as detailed in the management of new pieces.

Repairing.—If the tooth gets broken (a mishap which seldom occurs by use in the mouth) it can be replaced with another by grinding out the remaining portion of the broken tooth, and the gum which covers the fang, and then fitting a new one in the place. This tooth need not be soldered to the inside rim; it is sufficient to grind a small notch or groove in the

enamel which covers the lingual side of the rim for the pin of the tooth to fit into. The pin resting in the groove is covered with the body at the same time it is applied around the base of the tooth, and when this body is baked the tooth will become firmly fastened in place of the broken one. Any number of teeth that may be required can be replaced in this way. If it is desired to change the position of one or more teeth, or to make them longer, this can also be done as described above, with the additional precaution, to press softened wax upon the inside of the teeth and palatal arch of the denture before the others are removed,—this wax will serve as a guide or index as to the relative change to be made, and also to sustain the teeth in place while they are being fitted as desired to the denture. The wax soon becomes hard, and is readily removed as each successive tooth is ground and adjusted in its proper place.

When the teeth are thus fitted with each pin accurately pressed into the groove prepared for it, and the wax being placed upon the inside to support the teeth in the proper position, body is filled in around the base of the new ones, which are carved, trimmed, and brushed, so as to save the crowns of the teeth clean and properly defined. The wax is then carefully removed from the piece, and more body is filled in around the teeth upon the inside,—filling up the grooves over the pins, and then carving, trimming, etc., as before, to give it the desired form. This done, if the teeth are set a little apart, and it is desired to keep them in that position, take a small piece of asbestos and gently press it in between the teeth at the cutting edges; this will prevent them from being drawn together when the body is being baked. The piece is now ready for the furnace, but it should not be baked hard enough to gloss the newly-applied body; it should have more the appearance of Parian marble.

This being done, it is then withdrawn from the furnace and transferred to a cooling muffle, as before described. When sufficiently cool, the gum enamel is applied and baked with a sharp heat until it becomes smooth and glossy. To prevent the old gum from bleaching or becoming lighter colored in consequence

of repeated bakings, a very thin coating of fresh gum enamel should be lightly brushed over the entire enameled surface of the piece. The enamel thus applied should be mixed with water, quite thin, so as to flow evenly over the surface when applied with a camel's-hair brush. This should be done before the last baking, that the whole may be fused at the same time. Experience and judgment are essential requisites in order to produce good practical results. For example, if the carving of the body is not properly done, the form and shading of the gum and roof will not appear natural when the work is finished; if the gum enamel is put on too thick, it will produce a dark-red color; if not thick enough, it will be too light; if fused too hard, it will be liable to craze or crack; if not hard enough, it will be rough or granular; if the piece becomes gassed in baking, it will be porous and of a bluish color.

General Remarks.—The teeth of different persons vary as much as any feature of the face, and present as great a variety of expressions. Therefore, in the construction of artificial dentures, the dentist should select and arrange the teeth with special reference to each individual case. The length, size, form, shade, and position of the teeth should be varied to meet all the different physiognomical requirements that occur in dental practice.

This system also combines with great advantage the restoration of the face in cases where the muscles have become sunken or fallen in from loss of the teeth and consequent absorption of the alveolar processes. Here, again, the artistic skill of the dentist is brought into requisition. He should study the face of his patient as the artist studies his picture, for he displays his genius not upon canvas but upon the living features of the face; and of how much more importance is the living picture, that reflects even the emotions of the heart, than the lifeless form upon canvas! He should know the origin and insertion of every muscle of which the face is formed, and what ones he is to raise, otherwise he will be liable to produce distortion instead of restoration. This improvement consists of prominences made upon the denture of such form and size as to bring out each muscle or sunken portion of the face to its original fullness; and when these are rightly formed they are not detected by the

closest observer. There are four points of the face (of many persons) which the mere insertion of the teeth does not restore, viz., one upon each side beneath the malar or cheek bone, and also a point upon each side of the base of the nose, in a line toward the front portion of the malar bone.

The extent of this falling-in varies in different persons, according to their temperaments. If the lymphatic temperament predominates, the change will be slight. If nervous or sanguine, it may be very great. The muscles situated upon the sides of the face, and which rest upon the molar or back teeth, are the zygomaticus major, masseter, and buccinator. The loss of the above teeth causes these muscles to fall in. The principal muscles which form the front portion of the face and lips are the zygomaticus minor, levator labii superioris alæque nasi, and orbicularis oris.

These rest upon the incisor, cuspid, and bicuspid teeth, which, when lost, allow the muscles to sink in, thereby changing the form and expression of the mouth.

The insertion of the front teeth will, in a great measure, bring out the lips, but there are two muscles in the front portion of the face which cannot, in many cases, be thus restored to their original position; one is the zygomaticus minor, which arises from the front part of the malar bone, and is inserted into the upper lip above the angle of the mouth; the other is the levator muscle, which arises from the nasal process and from the edge of the orbit above the infraorbital foramen. It is inserted into the ala nasi, or wing of the nose and upper lip.

The prominences before mentioned, applied to these four points of the face, beneath the muscles just described, bring out that narrowness and sunken expression about the upper lip and cheeks to the same breadth and fullness which they formerly displayed. If skill and judgment have presided over all parts of the operation, the result will be highly pleasing and of practical utility.*

* Inasmuch as the improvement for restoring the face has been claimed by others, the reader is referred for the evidences establishing the claim of Dr. Allen to priority of invention to the historical record which appears in the old *American Journal of Dental Science* of 1845. In the published proceedings of the American Society of

Dr. Hunter's Formulas and Modes of Practice.—The following methods of compounding and applying the gum materials, as practiced by Dr. W. M. Hunter, were taken from his latest published descriptions, and have formed the basis, in a large measure, of more modern methods of compounding the silicious materials used in the manufacture of body and gum enamels.

The following is a description of the materials and compounds employed :—

"*Silex* should be of the finest and clearest description, and kept on hand ready ground, the finer the better.

"*Fused spar* should be the clearest felspar, such as is used by tooth manufacturers for enamels, completely fused in a porcelain furnace, and ground fine.

"*Calcined borax* is prepared by driving off the water of crystallization from the borax of commerce, by heating in a covered iron vessel over a slow fire, and it is better to use immediately after its preparation, as it attracts moisture. It should be perfectly clean and white, and free from lumps.

"*Caustic Potassa Optimus.*—Known also as potassa fusa.

"*Asbestos.*—Take the ordinary clean asbestos, free it from all fragments of talc or other foreign substances, and grind fine, taking care to remove any hard fragments that may occur.

"**Granulated Body.**—Take any hard tooth material (I use the following formula: spar 3 oz., silex 1 ½ oz., kaolin ½ oz.) and fuse completely. Any very hard porcelain, wedgewood ware, or fine china will answer the same purpose. Break and grind so that it will pass through a wire sieve, No. 50, and again sift off the fine particles which will pass through No. 10 bolting cloth. It is then in grains about as fine as the finest gunpowder.

"**Flux.**—Upon this depends the whole of the future operations, and too much care cannot be taken in its preparation. It is composed of silex 8 oz., calcined borax 4 oz., caustic potassa

Dental Surgeons of that year it will be seen that a medal was awarded to one of its members, inscribed, "Awarded to Dr. John Allen, for his invention for restoring the contour of the face, August, 1845." This, in connection with the fact that no other record upon this subject is found in our dental literature, fixes the date of this improvement.

1 oz. Grind the potassa fine in a wedgewood mortar; gradually add the other materials until they are thoroughly incorporated. Line a Hessian crucible (as white as can be got) with pure kaolin, fill with the mass, and lute on as a cover a piece of fire-clay slab with the same. Expose to a clear, strong fire in a furnace with coke fuel for about half an hour, or until it is fused into a transparent glass, which should be clear and free from stain of any kind, more especially when it is used for gum enamels. Break this down, and grind until fine enough to pass through a bolting cloth, when it will be ready for use.

"**Base.**—Take flux 1 oz., asbestos 2 oz., grind together very fine, completely intermixing. Add granulated body 1½ oz., and mix with a spatula to prevent grinding the granules of body any finer.

"**Gum Enamels.**—No. 1. Flux 1 oz., fused spar 1 oz., English rose 40 grains. Grind the English rose extremely fine in a wedgewood mortar, and gradually add the flux and then the fused spar, grinding until the ingredients are thoroughly incorporated. Cut down a large Hessian crucible so that it will slide into the muffle of a furnace, line with silex and kaolin each one part, put in the material, and draw the heat up on it in a muffle to the point of *vitrifaction*, not *fusion*, and withdraw from the muffle. The result will be a red cake of enamel, which will easily leave the crucible, which, after removing any adhering kaolin, is to be broken down and ground tolerably fine. It may now be tested, and then (if of too strong a color) tempered by the addition of covering. This is the gum which flows at the lowest heat, and is never used when it is expected to solder.

"No. 2. Flux 1 oz., fused spar 2 oz., English rose 60 grains. Treat the same as No. 1. This is a gum intermediate, and is used upon platina plates.

"No. 3. Flux 1 oz., fused spar 3 oz., English rose 80 grains. Treat as the above. This gum is used in making pieces intended to be soldered on, either in full arches or in the sections known as *block-work*. It is not necessary to grind very fine in preparing the above formulæ for application.

"**Covering.**—What is termed covering is the same as the formula for gum *minus* the English rose, and is made without

any coloring whatever when it is used for tempering the above gums which are too highly colored, and which may be done by adding, according to circumstances, from one part of covering to two of gum, to three of covering to one of gum, thus procuring the desired shade. When it is to be used for covering the base prior to applying the gum, it may be colored with titanium, using from two to five grains to the ounce.

"**Investment.**—Take two measures of white quartz sand, mix with one measure of plaster-of-Paris, mixing with just enough water to make the mass plastic, and apply quickly. The slab on which the piece is set should be saturated with water, to keep the material from setting too soon, and that it may unite with it.

"**Cement.**—Wax 1 oz., rosin 2 oz. The proportions of this will vary according to the weather; it should be strong enough to hold the teeth firmly, and yet brittle enough to chip away freely when cold. A little experience will enable any one to prepare it properly.

"After the plates are perfectly adapted to the mouth, place wax upon each, which trim to the proper outline as regards length and contour of countenance, marking the proper occlusion of the jaws and the median line. These waxen outlines are called the *drafts*, and are carefully removed from the mouth, and an articulation taken by which to arrange the teeth.

"When the absorption is considerable and the plate, in consequence, is rather flat, it is necessary to solder a band or rim along the line where the upper draft meets the plate, about one-sixteenth or one-eighth of an inch wide, and fitting up against the outline of the draft. When the ridge is still prominent, the block will not, of course, be brought out against the lip so much, and a wire may be soldered on instead of the wider band. I think one or the other necessary, as it gives a thick edge to the block, rendering it far less liable to crack off than if it were reduced to a sharp angle; it also allows the edge of the plate to be bent in against the gum, or away from it, as circumstances may require, and affords in many cases a far better support for the plates than can be given to one in which the band is *struck up*, or the edge turned over with pliers, where the block must extend to the edge of the plate. Some few cases do occur where

the band may be struck as far back as the bicuspids with advantage, and some in the lower jaw where it is necessary to solder on the band, but the general practice is not so.

"The upper teeth are first arranged on the plate antagonizing with the lower draft, supported by wax or cement, or both. Then remove the lower draft and arrange the lower teeth so that the coaptation of the cutting edges of the teeth shall be perfect as desired. The patient may now be called in again, and any change in the arrangement made to gratify his or her taste or whim. Now place the plates with the teeth thereon on their respective casts, oil the cast below the plate, and apply plaster-of-Paris over the edge and face of the teeth and down on the cast, say an inch below the edge of the plate. This will hold them firmly in their place while you remove the wax and cement from the inside and fit and rivet backs to the teeth. When backed, cut the plaster through in two or more places, and remove. Clean the plate by heating. Cut the plaster so that while it will enable you to give each tooth its proper position, you can readily remove it from the teeth when they are cemented to the plate. Adjust the sections of plaster and the teeth in their proper positions. The plaster may be held by a piece of soft wire. *Cement* the teeth to the plate and strengthen the cement by laying slips of wood half an inch long along the joints and against the teeth. (I generally use the matches which are so plenty about the laboratory.) Remove the sections of plaster, being careful not to displace any of the teeth. If it be intended to cover the strap with enamel, you should solder a wire after backing, and previous to replacing the teeth, along the plate parallel with the bottom of the straps, and about one-eighth or one-fourth of an inch from them.

"The teeth are now backed and cemented to the plate, and present an open space between the plate and the teeth, which is to be filled up with the base, using it quite wet to fill up the small interstices, filling in the rest as *hard and dry as possible.* Fill the cavity *between* the plates in the same manner, and oil the edge. Oil the surface of the base, envelop in the investment (precisely as you would put an ordinary piece into plaster and sand for soldering), and set on a fire-clay slab previously saturated

with water. When hard, chip away the cement, cooling if necessary with ice, until it is perfectly clean. Along the joints place scraps and filings of platina very freely, and cover all the surface you wish to enamel with coarse filings, holding them to their place by borax ground fine with water. Apply pure gold as a solder quite freely, say two dwt. or more to a single set. Put in a muffle and bring up a gradual heat until the gold flows *freely*, which heat is all that will be needed for the base; withdraw and cool in a muffle. Remove the investment and fill up all crevices and interstices not already filled, with covering No. 2; cover the straps and base with the same, about as thick as a dime, and cover this with gum No. 2 about half that thickness. At the same time enamel the base in the chamber and cover with thick, soft paper. Set the plate down on the investment on a slab, with the edges of the teeth up. Fuse in a muffle, and the work is completed. Blemishes may occur in the gum from a want of skill in the manipulation; should such occur, remedy by applying gum No. 1.

"Should the patient object to the use of platina as a base, the work can be made as above on an alloy of gold and platina 20 carats fine, and soldered with pure gold, etc., as above. In all cases, however, where it is used, the upper plate should be made as I have described above, but with platina any kind of plate can be used.

"**Ordinary Alloy.**—Blocks may be made and soldered to the ordinary plate if the absorption is sufficient to require much gum, without any platina. Arrange the teeth on wax on the plate, fill out the desired outline of gum, and apply plaster one-fourth of an inch thick over the face of the teeth, wax, and cast. When hard, cut it into sections (cutting between the canines and bicuspids), remove the wax from the plate and teeth, bind the sections of the plaster mold thus made to their places with a wire, oil its surface and that of the plate, fill in the space beneath the teeth with the base, wet at first, but toward the last as hard and dry as possible, and thoroughly compacted. Trim to the desired outline on the inside, oil the base, and fill the whole palatal space with investment, supporting the block on its lingual side. Remove the plaster mold, and cut through the

block with a very thin blade between the canines and the bicuspids. Take the whole job off the plate, and set on a fire-clay slab with investment, the edges of the teeth down; bring up the heat in a muffle to the melting point of pure gold. When cold, cover and gum with No. 3 gum and covering.

"Another mode is to back the sections with a continuous strap (using only the lower pin), fill in the base from the front, use covering and gum No. 3, finish at one heat. When the blocks are placed upon the plate, the other pin is used to fasten the gold back, which is soldered to it and the platina half-back; neither of these backs need be very heavy, as soldering the two together gives great strength and stiffness. Very delicate block-work can be made in this way, and it is applicable also where a few teeth only are needed.

"A very pretty method, where a section of two or four teeth (incisors) is needed, and only a thin flange of gum, is to fit gum teeth into the space, unite by the lower platina with the continuous back, and unite the joint with gum No. 3. A tooth left ungummed by the manufacturer would be best for the purpose. The same may be applied to blocks for a full arch, remembering not to depend entirely upon platina backs.

"The method I prefer for full arches on ordinary plate is to take a ribbon of platina, a little wider than the intended base, and of the length of the arch, cut it nearly through in five places, viz., between the front incisors, between the lateral incisors and canines, and between the bicuspids. Adapt it to the form of an alveolar ridge with a hammer and pliers, and swage on the plate along where the teeth are to be set. Solder up the joints with pure gold, and proceed to back the teeth, etc., as before; making preparations for fastening, and removing the slip of platina from the gold plate before enveloping in the investment, when proceed as before.

"When the teeth are arranged, insert four platina tubes, about one line in diameter, two between the molars, and two between the cuspids and bicuspids, and solder to the platina base. These are designed, after the teeth are finished, to be the means of fastening to the gold plate, either by riveting in the usual way, or by soldering pins to the gold plate passing up through the

tubes, fastening with sulphur or wooden dowels. By these methods we are enabled to readily remove the block and repair it, should it meet with any accident, and also, in case absorption should go on, to restrike the plate or to lengthen the teeth. The rim should be put on the gold plate after the block is finished; it gives additional strength and a beautiful finish.

"**Memoranda.**—In preparing material always grind dry, and the most scrupulous cleanliness should attend all of the manipulations. In all cases where heat is applied to an article in this system, it should be raised gradually from the bottom of the muffle and never run into a heat. Where it is desired to lengthen any of the teeth, either incisors or masticators, or to mend a broken tooth, it may be done with *covering*, properly colored with platina, cobalt or titanium.

"In preparing a piece of work, wash it with great care, using a stiff brush and pulverized pumice-stone. Bake over a slow fire to expel all moisture, and wash again, when it will be ready for any new application of the enamel. Absorption, occurring after a case has been worn some time, by allowing the jaws to close nearer, causes the lower jaw to come forward and drive the upper set out of the mouth. By putting the covering on the grinding surface of the back teeth in sufficient quantities to make up the desired length, the coaptation of the denture will be restored, and with it the original usefulness.

"Any alloy containing copper or silver should not be used for solder or plate, if it is intended to fuse a gum over the lingual side of the teeth, as it will surely stain the gum. Simple platina backs alone do not possess the requisite stiffness, and should always be covered on platina with the enamel, and on gold with another gold back. In backing the teeth, lap the backs or neatly join them up as far as the lower pin in the tooth, and higher if admissible, and in soldering be sure to have the joint so made *perfectly soldered*."

Dr. Haskell's Methods.—"It should be borne in mind that the strength of this work depends mainly upon the *metal*, and not upon the *porcelain*, though the latter adds to its strength. While platinum is a very soft metal, yet, by means of various devices, the plate, with the teeth properly soldered on, and

ready for the porcelain, can be made very stiff and strong, therefore everything that can be done to secure a strong foundation should be carefully observed.

"The plate should be of the best French material (not melted scraps and old plates), 29 to 30 gauge for the upper, and 26 to 28 for the lower, and should be swaged on Babbitt metal dies. The plate is then tried in the mouth, and if the fit is found to be correct, arrange the articulating wax, secure the 'bite,' and make the articulating model.

"The back of the plate should be doubled, for the following reasons: It imparts increased strength; leaves some margin for change, in case of necessity, after the work is in the mouth; protects the edge of the porcelain; and admits of a neater finish. This 'doubler' should be about three-sixteenths of an inch wide, with the edge turned up slightly to receive the porcelain. Around the outer edge, solder a flattened wire, one-sixteenth of an inch wide, or less, and 22 gauge, bringing the ends to meet the turned edge of the doubler. This strengthens the plate, and affords a good round finish to the edge, as well as protection to the porcelain. This is easily put on after a little practice, and is far preferable to *turning* the edge of the plate with pliers, or otherwise. Pure gold should always be used for soldering, and with just enough borax (using very little) to give direction to the flow of solder.

"Then comes the arrangement of the teeth, and this should always be done in the mouth, the articulating model being only a preliminary guide; for by the mouth alone can one determine the correct expression and arrangement desired; and it is just here that three-fourths or more of the artificial dentures fail in an utter lack of artistic skill. In this work there is ample opportunity for the display of taste and skill, so that perfection itself is attained at the hands of the true artist.

"The *investing* process comes next. First, a coat of shellac over the teeth to prevent etching (although, if this occurs, it is not a matter of much account, as the baking remedies it). Then a *thin* coat of clear plaster; next plaster and asbestos, one part of the latter to two of the former. Let the portion under the plate extend at least one inch back of the latter, as this

bottom portion is to be retained on which to bake the case; invest the whole one-half inch thick. Warm the case until the plate is sufficiently heated to remove the wax easily; dash boiling water over it (this is the best method to remove wax adhering to teeth and plate in all kinds of work). The backings should be *continuous* and be *lapped* on to the plate, for in this is the mainstay of the work for strength. Cut patterns in tin or lead, three pieces, one for the six front teeth and one for each side, lapping over the cuspid teeth; the foot-piece should lap on to the plate about three-sixteenths of an inch. No borax is needed. The gold should be melted and rolled into a ribbon as thin as possible, and cut in small pieces and laid under the lap, or foot-piece, and a piece under each pin. The backings can be fitted more easily by splitting the foot-piece. The most convenient method of soldering is in the furnace, being careful not to let it remain too long, so as to fuse the enamel on the teeth. If a pin should fail to solder, it is immaterial, as the 'body' will hold it.

"After cooling, remove the plaster and save the base. If any teeth are etched, sandpaper them and remove every particle of plaster; with a sharp instrument scarify the surface of the plate. Place the plate on the articulating model, and if it is sprung, press it into place, which is very readily done.

"The 'body,' and enamel or gum color, as prepared by S. L. Close, is the only reliable material to be had, as Dr. Allen no longer furnishes it for the trade. Apply the 'body' mixed with water, quite thin, by means of an oval-pointed knife, occasionally jarring with handle of spatula, and as the moisture comes to the surface, absorb with a cloth; after it is well-filled into all interstices, apply it thicker, jarring, absorbing, and packing hard, until enough is on the outside to produce the proper shape and contour of the lips. Then apply, with the *curved* point of the knife, the body to the lingual side of the plate, same as on the outside, but only a thin coat on the plate. Trim around the necks of the teeth, remove all particles from *between* with a quill toothpick, and brush all particles off the surface of the teeth and exposed portions of plate, and the case is ready for baking.

"The Philadelphia furnace, sold by all dealers in dental goods, we prefer. It is always best to use the largest size, No. 1, yet

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No. 2 will do if the larger size cannot be had. Be sure of a good draft. The furnace can be used as it comes; a better plan is to knock the bottom out of the lower section, get longer bars, that will extend some distance through the front, the two center ones at least eighteen inches. Build a hearth, two bricks thick and three feet square; build an enclosure of brick, about twelve inches high, large enough to set the furnace on, and line with fire-brick. Provide a sheet-iron cover for the front, to close the draft.

"In setting the 'muffle,' see that the vent hole in the top is clear; this is for escape of gas that may be in the muffle and would injure the work. Fasten the front end with fire-clay, but leave the back end free.

"The fuel to be used must be anthracite coal or else coke; Lehigh, range size, is the best.

"A sheet-iron shelf, the edge bent into the space between the furnace and cover, and with a leg riveted to it and resting on the long bars, is needed to set the case on, to heat up, and run into the muffle gradually. Set the case ten or twelve inches from the opening, move forward, every ten or fifteen minutes, a couple of inches, until it is in the muffle; place it within two inches of the back, and close the door. If the heat is right, five or ten minutes will suffice; still, it must be looked at so as not to get too much heat. This first bake should be only a glaze. Remove to a muffle on the hearth and close up tight. When cool, place on the model, and, if sprung, press it into place. Next fill up all the cracks with very thin body, jarring with handle of the spatula often, so that the material will fill up thoroughly; then spread on thicker until the proper shape and fullness are secured, trimming around the teeth, and doing as previously described, and bake as before. After cooling, the enamel is to be put on the same as the body, applying only a thin and uniform coat. The rugæ can be produced in the body or in the gum. The enamel should have a thoroughly glossy appearance when ready to be removed from the furnace. Heated cooling muffles are unnecessary, as the case itself will heat the muffle all that is necessary.

"Lower sets are better without a binding, as it is sometimes

necessary to file or grind away the edge. Use plate No. 8, or even thicker, and solder on the edge a narrow strip, *flat*.

"The case is finished by filing and polishing the exposed metal surface, not doing anything to the upper surface.

"A 'defined' air-chamber is rarely necessary,—a Cleveland chamber, never. Raise the plate over the hard palate with a thin film of wax on the plaster cast, chamfering off the edges completely; scrape the plaster model across the back, except right in the center, according to the softness of the palate.

"This work *is not advisable* for partial sets, except in some partial lower cases where there are no detached teeth. In these cases, the plate should be at least two thicknesses across the back of the front teeth, and resting well up on the necks of the same.

"Very few seem to know how to *prepare* a case for repairing. Invest it in plaster and asbestos at least one-half of an inch deep; place in the muffle before lighting the fire, and allow it to remain with the door open, as the fire comes up, until it is *red hot;* then remove, cool, and thoroughly clean off the plaster, preserving the *base*, and it can be run into the furnace with as little danger of cracking as if it had never been worn.

"Grind out the remains of the teeth below the margins of the gum; select a *rubber* tooth, as it is easier to get and just as good as one made for this work, filing off the pins; hold with wax until a little plaster and asbestos can be placed over it and the adjoining teeth; thoroughly remove the wax and put on *repairing* body, and bake; cool, put on the gum, having previously ground off a portion of the old gum if it is a very old case, and put on just a little new, and bake as at first.

"If blisters occur, grind into them and fill with *body and gum*, three to one, press hard, and enamel."

Dr. Field's Methods.—"When the platinum has once touched the metal dies, never place it under the blowpipe without its having been *thoroughly pickled.* This is often neglected, and the consequence is that the plate will become more or less discolored from the absorption, under heat, of the baser metal into the platinum. When the teeth are properly arranged with wax on the plate, as directed by Dr. Allen, invest, *but use no sand*, simply plaster and asbestos. My reason for this I will give further on.

"After the investment has become sufficiently hard to handle, the backings may be adjusted; and here I shall differ somewhat with Dr. Allen, for, instead of the *continuous* backing, I back each tooth separately, and for two reasons, one of which is, that I think my work will be *stronger* when completed, by allowing the body to be well worked in between, below, and completely around the teeth without a platinum wall, as it were, separating the body on a line running completely around the alveolar ridge, and only just touching over the top of this platinum.

"My second reason is that, should the teeth be drawn out of place any, as is sometimes the case by the cracking of the investment and pulling away from the plate, the single backing of each tooth admits of a much easier and more perfect readjustment than when the backing is continuous. Make the backings of a somewhat V shape, that is, let them be a little narrower at the top than where they come in contact with the plate; bend up the lower part of the backing to the extent of about one-sixteenth of an inch, and at such an angle that when placed in position behind the platinum pin, to which it is to be soldered, it will fit fairly and squarely on the plate; put in position and press the pin down on it, first having placed a piece of, say number 20, gold foil, folded two or three times, one-sixteenth of an inch square, against the backing, so that when the pin is bent down upon it, it will hold it from slipping away; then with a pair of ordinary plugging pliers squeeze the foil up to and around the pin; then place one or two pieces of solder (pure gold) just *behind*, and close against, the heel of the foot-shaped backing. By placing it here, the danger of it slipping away when the borax calcines under heat is avoided. The *less solder* you use, and still have your teeth fastened, the better, for the reason that the gold flowing at a less heat than that required for the fusing of the body, *the gold is in a state of fusion when the body has set*, and there will be no adhesion between the gold and the body. Now solder as most convenient. I find the Fletcher furnace an admirable contrivance for this purpose, ten minutes being all the time necessary to complete the work. Remove the investment carefully, *and preserve it all* for future use. The plate is then

tried in the mouth, and the teeth nicely adjusted to those with which they are to antagonize.

" Everything is now ready for the first baking. Pour out upon a clean butter plate the amount of body required, into which pour sufficient pure water to make a *thin* paste, and then begin the work of molding and carving the piece by filling in between and under all the teeth, tapping your plate gently from time to time; this will bring the water to the surface and settle the body into every nook and crevice. After each tapping absorb the surface water with a clean napkin; by so doing, you will the better hold the body to its place and prevent its running where not wanted. Build over the roots of the incisors and cuspids *boldly*, leaving a corresponding depression between the teeth; thus when the piece is completed, you will have that natural and life-like appearance as of the roots of the teeth showing slightly through the gum.

" Now take that part of your investing material that covered the teeth when the piece was soldered, grind it up fine, and with it make a cushion an inch thick, on the slab that is to hold the case; then place your piece on this base, *teeth downward*, take a small spatula and work the powdered material well up against the teeth, so that the bearing shall be equal under every tooth; this, if properly done, will prevent any *drawing away* of the teeth from their proper position, as is frequently the case when the plate is placed in the muffle with the teeth upward, the cause being the shrinkage of the body; and now comes my reason for *not using sand* in this investing material, viz., the sand, acting as a flux, would attach itself more or less to the teeth themselves, and I have seen this thing carried so far, when the heat was a little too high, as to solidly fuse teeth and slab together.

" The piece is now ready for the first baking, and this should be carried no farther than to *shrink* the body as much as possible, not going beyond a semi-fuse. After this is completed, and the case cooled, proceed to fill up all cracks and shrinkage by the application of more body, when the case is ready for the second baking. This should be done with the plate reversed,

teeth upward, using for a support that part of the investment which came in contact with the platinum, and which should be preserved unbroken. In the second baking of the body, care should be taken that it be not overdone. A piece properly baked will present a beautifully granulated appearance, the tips of the granules sparkling like little dewdrops. Carrying the heat beyond the stage necessary to produce this effect vitrifies the body, thereby very much lessening the strength of the work when completed.

"If now it is found that a third body is not required (and it rarely is, if proper care has been taken with the work so far, although occasionally it may be necessary), proceed with the enameling as directed by Dr. Allen. Should there be any little rough spots on the teeth, caused by overheating when soldering, paint them over with a little clean pulverized borax mixed with water; this will flow the tooth enamel, and cause them to come out from the muffle as bright and smooth as when they first left the factory.

"The work is now ready for its third or final baking, which should be with a quick, sharp fire. When fused, draw to the front part of the muffle; put in the muffle plug, then dump the fire, and leave until the furnace is *cold;* by so doing, the case is well annealed, and all danger of checking the enamel avoided. Twenty or thirty minutes now are all that are necessary for what little finishing the plate will require, when it will be ready for the mouth.

"Let it be remembered by the beginner that on the *carving of the first body* largely depends the artistic beauty of the work. Keep your patient's face well before you in your mind's eye, and reproduce in porcelain all those little minor details which, when properly arranged and blended together, shall so counterfeit nature's handiwork that that of man can hardly be detected."

Dr. Ambler Tees's Methods and Formulas.—"Continuous-gum work is mounted upon a swaged plate of pure platina, about No. 29, American gauge. The lower plate, to insure strength, is made of two pieces soldered together, one being large enough to allow for a rim. In a partial lower set, an additional piece of iridionized platina is soldered to the part

covering the lingual gums of the remaining natural teeth. Plain teeth, with single long pins, made for the purpose by tooth manufacturers, are soldered to the plate with pure gold (24 k.), which alone is used as a solder in this work, since the copper and silver contained in alloyed gold will discolor the *gum enamel.* The silicious materials called *body* and *gum enamel* are then applied around the necks of the teeth, and upon the lingual portion of the plate, by means of small spatulas, and carved to imitate the contour of the gum.

"The investment used for retaining the teeth in position while being soldered is composed of two parts of plaster and one of asbestos; before applying this, the teeth should be coated with a thick varnish of shellac and alcohol, to prevent the teeth being etched in soldering. The backing is fitted most conveniently by making it of three pieces; the pins are bent down over it, and soldered with pure gold. After soldering, the investment is removed, and the teeth and the plate brushed with soap-suds and powdered pumice-stone and washed off with clean water. The *first coat of body* is then applied, moistened with clean water to the consistency of soft putty, as a foundation, no effort being made to imitate the contour of the gums; separations, however, are made between the teeth, so that the body may fuse around each tooth separately, and prevent it being drawn from position by the shrinkage of the body. It is then *fused* in the muffle, and placed in a *cool* muffle for thirty minutes. After adjusting it upon the articulator, it is ready for the *second coat of body.* In applying this, an artistic effort is made to imitate the contour of the gums; and by making elevations and depressions in appropriate position, the lights and shades of the natural gums may be simulated, especial attention being paid to the rugæ. This coat is *vitrified* and not fused. After it is cool and again adjusted upon the articulator, the *gum enamel* is applied, the spatulas being used for the purpose. It is moistened with clean water, a little thinner than the body, and laid on a little at a time, about the thickness of twenty-six plate. This is *fused* and allowed to remain in the cool muffle for an hour and a half. The platina is then rubbed with pumice-stone, an orange-wood stick being used, and the rim filed, stoned, and burnished, when the set will be ready for the mouth.

"When a set is to be repaired, the mucus should be burnt off before any fresh body is applied. To accomplish this, it should be invested in plaster and asbestos, and heated to redness over a gas or coal-oil stove, or upon the coals in a range. The investment should then be removed, the set washed with soap-suds and pumice-stone, and again heated to redness upon a slide in the muffle. The new tooth, after being carefully ground against the gum, is held in position by plaster and asbestos on the palatine surface, a very small quantity being sufficient; after it has set, *gum enamel* is worked into the joint at the neck and fused in the muffle. The body and gum enamel are then applied to the palatine surface, after the pin is soldered to the old backing, and then fused. This plan obviates the old method of investing the whole set in plaster and asbestos.

"Dr. Allen's formulas have never been published. For many years Dr. S. L. Close, of New York, at one time connected with Dr. Allen, has manufactured the materials for the profession, and these can be relied upon. From time to time, however, materials have been placed upon the market purporting to be Allen's, which have checked very much in cooling."

Body and gum enamel for continuous-gum work, was manufactured by the late Dr. Tees, according to the following formulas and methods of compounding.

He furnished three shades of gum enamel—pale, medium, and dark. The body as made by him is composed of

Felspar, ...	2 ozs.
Dental glass, ...	8 dwts.
Kaolin, ...	3 dwts.

The materials are ground together in a moistened state, in a wedgewood mortar, for about an hour; then dried; again ground for ten minutes, and fused in a crucible in a coke fire, or upon a slide in the muffle. After being pulverized, two grains of titanium to each ounce are added and thoroughly mixed.

The gum enamel is composed of

Felspar, ...	2 ozs.
Dental glass, ...	10 dwts.
Gum frit, ...	½ dwt.

These materials are ground together in a moistened state, for

about an hour, in a wedgewood mortar; then dried, ground again for ten minutes, and fused—upon a slide rubbed with fine, dry silex—in the muffle of the furnace; again pulverized, and sufficient additional gum frit mixed in with a spatula to give the desired shade.

The materials fuse kindly and will not check in cooling.

Application of Continuous Gum to Partial Sets.—The following method of constructing partial sets of artificial teeth with continuous gum is taken from a practical and well-written paper on this process by Dr. W. B. Roberts:—

"Partial cases may be made of continuous gum; but the work is so various in its nature, that the dentist must necessarily depend much upon his own judgment. Difficult cases will constantly present themselves that will require the exercise of much study and ingenuity, in which the general instruction that can be given in words may be of but little service. The first attempt of this kind in my own experience was in replacing two central incisors. Taking two continuous-gum teeth, I placed upon them a platinum lining, slitting this down along the edge of one tooth nearly through the piece and up the edge of the other tooth by a parallel cut, leaving the two parts joined together by a narrow slip. This allowed sufficient motion between the teeth, so that they could be adjusted as desired. I then placed a small piece of tissue paper on the plaster model, covering the spot to be occupied by the teeth and gum, to prevent the adhesion of the body to the plaster, and holding the two incisors in their places, worked the body into all the depressions of the gum and around the roots of the teeth. It was then all removed from the model, and placed in a paste of pulverized silex, or plaster and asbestos, upon a slide, and baked as described for full sets. The little slip of platinum kept the two teeth in place. The work shrunk somewhat; but this was remedied by again placing the piece upon the model with the intervention of tissue paper covered with a thin coating of body. Into this I pressed the piece till it occupied its true place, and then filled in again with more body all the crevices around the roots of the teeth, and rebaked.

"After enameling, if the work has been carefully and skilfully

done upon this plan, it will be as fine a piece in appearance and fit as can be made. It may then be soldered to a gold plate, and the little strip of platinum between the teeth be cut out. With the body and gum formerly in use many difficulties were encountered from discoloration of the gum, or from other injuries incurred in soldering. But with Roberts' material, these are easily avoided, and the piece can be treated the same as block or single gum teeth. In partial sets on entire plates of platinum trouble has sometimes been experienced by the enamel giving way upon the small narrow points that connect the teeth with the plate by the shock occasioned in biting, consequently I have left these points uncovered, and used two or three thicknesses of platinum to give greater strength. But where this is likely to occur, gold plates would be preferable, if nicely adapted with single gum teeth, or blocks of continuous gum, as the case might require. I have also applied continuous gum in cases where the natural teeth, from one to five in number, were left in the mouth, by making the plates as in full sets, cutting out around the natural ones, and raising a small bead, or placing a light wire around, about one-eighth of an inch or more from the teeth, against which the gum or body is to be finished. The points around the teeth are to be left free, in order to be burnished down in cases of imperfections caused by the difficulty of obtaining exact impressions in these places. In such cases I have sometimes formed a strong standard of several thicknesses of platinum fitting closely against one or more natural teeth, leaving a loophole through which to run a gold clasp for afterward securing the artificial set.

"I have also secured the gold to the standard by rivets of platinum, and sometimes by two or three gold screws, not providing, in these cases, the loophole. These methods are to be preferred to using solder for fastening; for, in case of repair, the clasps are easily removed without leaving any foreign substance; but in case of soldering, however carefully they may be removed, there will remain some alloy, which in the baking heat to which the piece is to be exposed will be incorporated with the platinum. Even so small an amount of silver as may be in gold coin used for solder will communicate a yellowish tinge to the gum, spoil-

ing the whole work. Many operators in their early practice experienced this result, and learned that no alloys, especially of silver or copper, can be admissible for soldering this work. I have tried platinum clasps without success, as no elasticity could be obtained, and therefore would not hold upon the teeth. Another source of mischief may properly be noticed in this place. In baking, especially with a new furnace, or with muffles lately renewed, either at the first or second heat, or it may be enameling, the piece is sometimes changed in its texture and color, as is supposed by the gases present, and the phenomenon is called gassing the piece. The body becomes porous and of a bluish color. When this occurs there is no remedy but to place it on the metallic die, remove the whole of the injured part, and replace it with a new coating of body and gum. The teeth are seldom, if ever, thus affected. As a precaution, the muffles should be well ventilated with holes for the passage of the heated air and gases."

CHAPTER XIII

RUBBER OR VULCANITE BASE.

While there are undoubtedly many important uses to which vulcanized India-rubber may be applied in the practical departments of dentistry, and for which it would be difficult to find an adequate substitute, yet there are accumulating evidences leading to the conclusion that its total abandonment, as a base for artificial dentures, by intelligent and conscientious practitioners everywhere, is an event of the not distant future.

This anticipated result, in respect of a material which has been almost universally employed as a base for the past twenty years, is assured by the confirmed and steadily increasing distrust of its suitableness for the purpose indicated, and the growing tendency in the profession to return to higher and less objectionable forms of substitution as respects both material and construction.

While the statements made in former editions of this work in regard to rubber as a base reflected, as the author believed, the estimate of its fitness by the profession generally, what is now written, we believe, embodies the present judgment of the mass of enlightened practitioners in reference to its unsuitableness and the necessity of its abandonment as a base. While the latter is a consummation "devoutly to be wished," there is warrant for the belief that the time when the use of the vegetable plastics, as a base, will be discarded will be contingent on the introduction of other equally inexpensive methods of substitution that are wholly free from the confessed and well-grounded objections that are attached to both rubber and celluloid.

General Properties of India-Rubber.—Caoutchouc, gum-elastic, or India-rubber exists as a milky juice in several plants, but is extracted chiefly from the *Siphonia cahuca*, which grows in South America and Java. It is discharged through the

numerous incisions made in the tree through the bark, and is spread upon clay molds, and dried in the sun, or with the smoke of a fire, which blackens it. The juice when first obtained is of a pale yellow color, of about the consistency of cream, and has a specific gravity of about 1.012. In the process of drying 55 per cent. is lost, the residuary 45 being elastic gum. It immediately coagulates, by reason of its albumin, on application of heat, the elastic gum rising to the surface. The specific gravity of the juice is diminished by inspissation, becoming 0.925 when hard, and cannot be permanently increased by any degree of pressure. When once stiffened by cold or continued quiescences it cannot be restored to its original condition of juiciness.

The inspissated juice, or crude rubber of commerce, is altogether insoluble in water or alcohol, but is readily soluble in ether deprived of its alcohol by washing, affording a colorless solution. On evaporation of the ether, the gum resumes its original condition. It swells to thirty times its bulk when treated with hot naphtha, and if triturated in this condition in a mortar, and pressed through a sieve, furnishes a homogeneous varnish employed in the preparation of a waterproof cloth.

Caoutchouc is soluble in the fixed oils, but is not readily decomposed by cold sulphuric acid or diluted nitric acid, and is unaffected by either muriatic acid gas, sulphurous acid gas, fluosilicic acid, ammonia, or chlorin, nor is it dissolved by the strongest caustic potash lye, even at a boiling heat, and is therefore highly esteemed as an appliance of the chemical laboratory. According to the experiments of Ure, Faraday, and others, caoutchouc contains no oxygen, as almost all other solid vegetable products do, but is a mere compound of carbon and hydrogen, in the proportion of three atoms of the former to two of the latter. From this property of resisting the corrosive action of acid vapors, and its tenacity of adhesion to glass, caoutchouc, when melted, forms a very excellent lute for chemical apparatuses.

Such are some of the properties of this remarkable product, the uses of which have been almost immeasurably extended since the first successful efforts to produce artificial induration by Charles Goodyear in 1844.

Compounding Rubber for Dental Purposes.—India-rubber is prepared for vulcanizing by incorporating with it, in varying proportions, either sulphur alone or some of its compounds, sulphur being an essential component of all vulcanizable gum compounds. For dental purposes, the coloring is effected in most preparations by the introduction of vermilion (sulphuret of mercury). These substances, properly combined, are subjected to artificial heat for a specified time, producing a hard, hornlike substance, possessing the qualities of lightness, strength, durability, imperviousness to fluids, insolubility in the oral secretions, unchangeableness on exposure to ordinary temperatures, etc.

Method of Constructing an Entire Denture in a Base of Rubber.—As the manipulations concerned in the construction of a full upper set differ in no essential respect from those required in the formation of a denture for the inferior arch, except as the two differ in conformation, requiring corresponding modifications of practice which will readily suggest themselves, it will be sufficient to describe the method of constructing an entire denture for the upper jaw.

An impression of the mouth is first secured in the usual manner, and, as has been stated, plaster-of-Paris is preferable to any other material for the purpose. As rubber, when rendered plastic by heat and subjected to pressure, receives a distinct and perfect impress of the face of the model, it is important that the latter should be as smooth upon its surface, and as free from faultiness of form or surface blemish, as possible. From the impression a plaster model is obtained, and if an air-chamber is required, it may be secured either by cutting out from the impression before filling in with plaster, for the model, or it may be raised upon the model after the latter has been separated from the impression. For the latter purpose, lead is often used, but sheet tin, cut to the required form, is preferable, as the former leaves a tenacious coating of oxid adhering to the plate.

A temporary or model base-plate is next conformed as accurately as possible to the face of the model, and for this purpose the *prepared gutta-percha*, paraffine and wax, or modeling compound worked into thin sheets may be used, or a die may be

secured and a trial plate struck up from block tin. Though the latter requires more labor, it gives more satisfactory and accurate results. The former may be softened either by subjecting them to a dry heat until sufficiently plastic, or by immersing in hot water. The face of the model being previously well saturated with cold water to prevent the wax or gutta-percha from adhering, the latter is pressed or molded accurately to the model with the fingers moistened with cold water, heating such portions from time to time as do not readily yield to pressure until an accurate adaptation of all portions of the plate is secured; then trim to the required dimensions.

Having fitted the temporary plate to the model, it is placed in the mouth with a wax guide or rim attached, when the latter is trimmed to the required width, fullness, and contour, and the "bite" of the under teeth secured; it is then removed and placed in its proper position on the model, which is placed in an articulator, with the antagonizing model, the latter being obtained in the manner described in connection with the metallic plate-base (page 417). The mode of procedure in cases of entire dentures for the upper and lower jaws differs in no respect from that practised when gold or other metallic plate is used as a base.

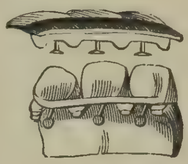
Arranging the Teeth.—Having secured an antagonizing model, the teeth are selected and arranged upon the temporary plate in the usual manner. The porcelain teeth used in this process are more commonly in the form of blocks or sections. The increased strength of attachment formed by the greater number of pins also renders them more permanent and enduring than single gum teeth. Teeth made expressly for rubber base were originally manufactured with plain platina pins, longer and heavier than those used in connection with metallic plates (Fig. 513); these, when used, were curved and pressed together, forming loops or hooks to prevent them withdrawing from the rubber. Subsequently, however, the detachment of the teeth was more securely and certainly provided against by the substitution of headed pins (Fig. 514), which rendered their withdrawal from the rubber impossible. For this valuable improvement the profession is indebted to the late Dr. S. S. White,

whose genius, enterprise, and intelligence were so long and unceasingly tributary to the needs of the dental practitioner.

Attention has already been called to Dr. Land's improvement in teeth. The form specially adapted to rubber work is shown

FIG. 513.

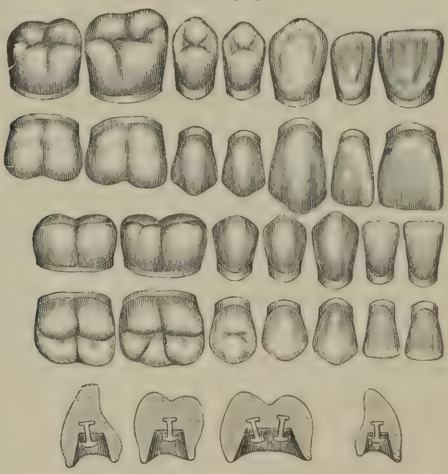
FIG. 514.



in the right-hand cut, Fig. 510, and also in the single tooth, same figure.

The latest design in the construction of porcelain teeth is shown in Fig. 515 The base of the tooth is countersunk, with headed pins inclosed within the cavity. It is claimed that their

FIG. 515.



close conformity in contour to the natural organs makes them much more acceptable to the tongue than teeth backed in the ordinary manner, renders articulation easier and more distinct, and prevents disclosure of artificiality when the mouth is opened.

In addition to these advantages, they allow greater facility of adaptation to the maxillary ridge. They are particularly adapted to rubber base with celluloid facing, or to celluloid base alone. Other forms of "plain teeth" are placed upon the market, and when they can be employed, more artistic results may be secured than is possible with the gum teeth.

Grinding and Jointing the Teeth.—In arranging the teeth, portions of the wax rim are cut away to form a bed for each tooth or block, as the case may be, grinding from the base of the latter and from their proximate edges until the proper position is assigned to the teeth, and the required antagonism is secured. When gum teeth are used, whether single or in the form of blocks, they should be united to each other laterally with the greatest possible accuracy, to prevent, as far as practicable, the intrusion of the gum material between them. To further provide against this, various expedients have been resorted to with the view of cementing or packing the joints in order to render them impervious to the rubber. The substances usually recommended for this purpose are plaster or finely pulverized silex or felspar moistened with dilute liquid silex, os-artificial, soluble glass, gold or tin foil, or fusible metal packed into the joints, etc. Of the more destructible substances mentioned, Professor Wildman very justly observes:* "All of these, in course of time, will yield to the action of the fluids of the mouth; and then the ill-fitted joints will be receptacles for soft particles of food, which will be more objectionable than having them filled with good, solid rubber. *The best filling is an accurately fitted joint;* when so made, if the enveloping plaster is of good quality and properly mixed, and no undue force is used in bringing the section of the flask together, there is little danger of the rubber insinuating itself into the joints." As properly remarked, there is no expedient which will so certainly and effectually exclude the rubber as *close-fitting joints*, and if the precaution is taken to secure an accurate and uniform coaptation of the ground surfaces where they unite in front, and the "enveloping plaster is of good quality and properly mixed,

* "Instructions in Vulcanite," p. 19.

Fig. 516.

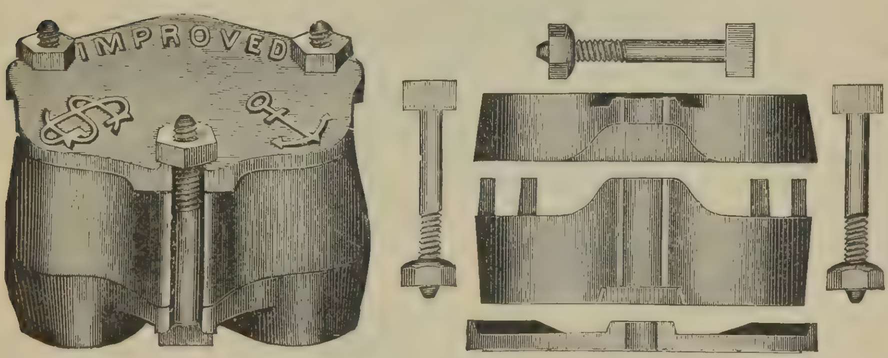
and no undue force is used in bringing the sections of the flask together," there will, at most, be but a very thin film of rubber, nearly imperceptible in the finished work, and wholly so in the mouth. To better effect the object stated, the writer has been accustomed, when uniting porcelain blocks, to use a small magnifying glass, which reveals inaccuracies of coaptation not apparent to the naked eye.

The teeth having thus been properly united and arranged, the wax rim supporting them on the lingual side should be cut away and carved with heated instruments, especially designed for that purpose, as represented in Fig. 516, until the required form and fullness are obtained, adding wax, if necessary, to the palatal portion of the plate, making it just enough thicker than that required in the completed set to compensate for waste in the process of final finishing. Any considerable excess of material should be avoided, since it will not only materially increase the labor of dressing the vulcanized plate, but tend to induce porosity or sponginess of the rubber under heat. A rim of wax should also be extended around the front and lateral borders of the plate, overlapping, somewhat, the extremities of the gum portions of the teeth. Wax used for the purposes indicated should be of the cleanest and purest varieties. A set modeled

in the manner described will present the appearance represented in Fig. 518.

Flasking.—The process having been conducted thus far,—any defects in the arrangement of the teeth having been previously corrected upon trial of the plate in the mouth,—the next step in the operation is the formation of a mold or matrix in which the gum material is packed and pressed preparatory to being vulcanized. In forming a matrix, a vulcanizing flask is used, the various parts of which are separately represented in Fig. 517. The lower section of the flask is first filled one-half or two-thirds full of plaster mixed with water to the consistency of cream. Into this the base of the model, previously moist-

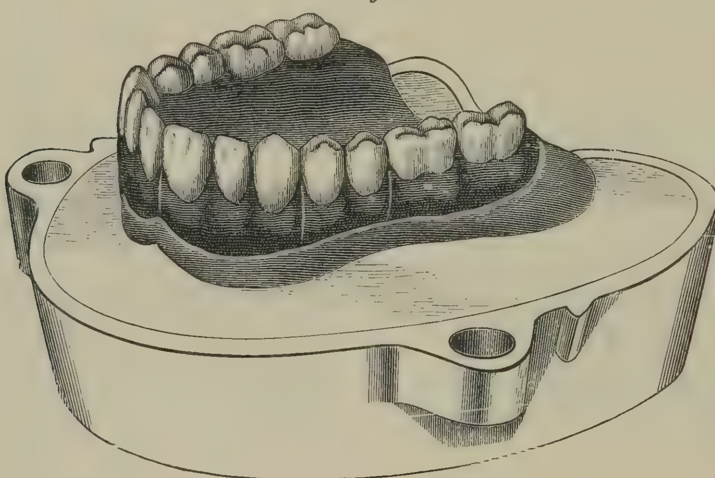
Fig. 517.



ened with water (the plate and teeth being attached to the model), is immersed and additional portions of the plaster added, if necessary, filling the cup even with the upper edge, and extending it up the sides of the model to the lower edge of the external rim of wax attached to the borders of the gum plate. The base of the model should be cut away, so that when placed in the flask the lower edge of the gum plate will extend but little above the level of the upper borders of the cup. The surface of the plaster is then trimmed smoothly, and coated with varnish and then oiled; all the exposed portions of the gum plate and wax are also oiled, leaving the surfaces of the teeth untouched. The several parts will now present the appearance represented

in Fig. 518. The upper section of the flask is next placed in its proper position over the lower—the slides formed in one, and corresponding grooves in the other, determining an accurate relation of the two pieces. Into the upper rim of the flask, plaster, mixed to the consistency before mentioned, is now poured, filling it completely. The lid or cap is then applied to the opening above, and the several parts of the flask brought firmly together, forcing the excess through the joints of the flask. As soon as condensation of the plaster takes place, the flask should be placed in a hot-air chamber or on a stove, and heated

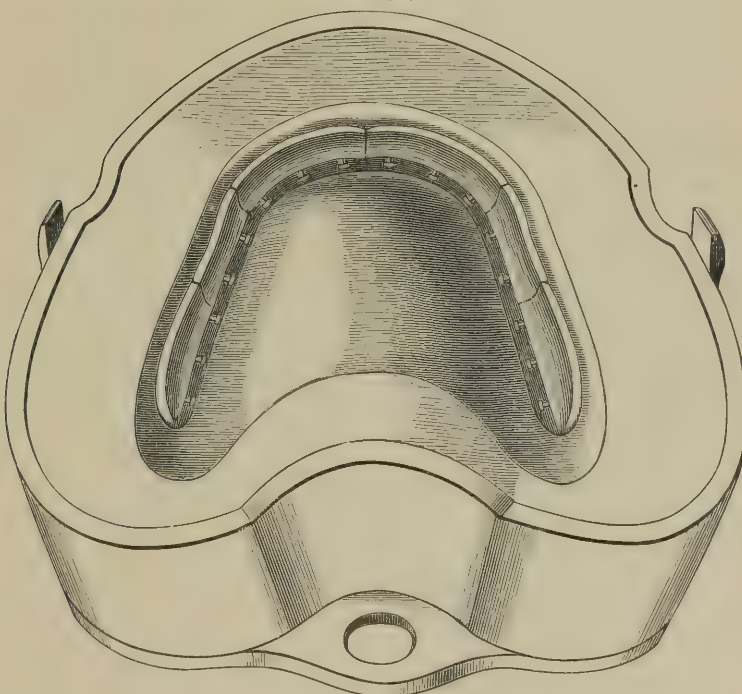
FIG. 518.



throughout *just sufficiently to soften, but not melt the wax.* The two sections of the flask are then carefully separated by forcing the blade of a knife or a small chisel-shaped instrument in at different points between them, the lid closing the opening above remaining in place. On separating the flask, the teeth, with the wax and temporary plate, will be found attached to the section of the matrix last formed, the portions of the crowns of the teeth not covered with wax being embedded in the plaster and their plate extremities presenting toward the matrix, as seen in Fig. 519. The base plate and wax should now be carefully detached with such instruments as will best enable the operator to work

out confined portions around the platinum pins and from the interstices between the teeth, being careful at the same time not to deface the plaster surface of the mold. To relieve the matrix more perfectly of all traces of wax not accessible to instruments, the section containing the teeth may be subjected to a heat sufficient to induce its complete absorption by the plaster. The flask should be heated gradually, otherwise the contents may be sud-

FIG. 519.



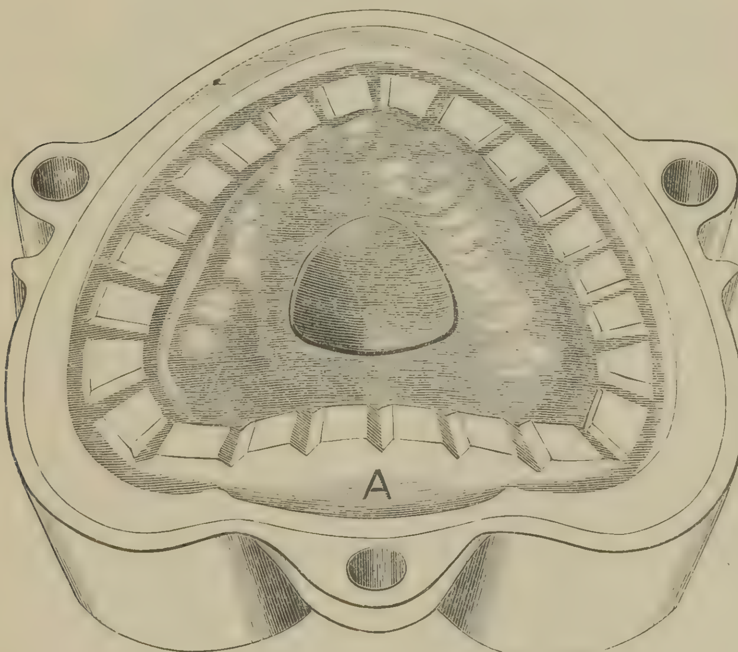
denly and forcibly ejected, in consequence of the too rapid evolution of vapor.

Before packing the material, provision should be made for the escape of any excess when the matrix is filled and the two sections of the flask are forced together, permitting the latter to close upon each other in exactly the same manner as before the introduction of the gum. If the vulcanizable substance becomes

engaged between the surfaces of the plaster around the matrix, the vulcanized base will be increased in thickness just in proportion to that of the interposed layer of gum, and hence the teeth of replacement will be relatively elongated. This increased thickness of the base and consequent changed relation of the teeth to the maxillary ridge and to those of the opposing jaw, if but slight, may be immaterial in the application of full sets of teeth; but it is far different in the construction of partial pieces, where the perfection of the finished work depends in so great a degree upon a faultless preservation of the exact position originally assigned to the organs of replacement in the several vacuities on the ridge. If, for example, in replacing the superior incisors, the approximation of the two sections forming the mold is obstructed by the intrusion of the gum material between the plaster surfaces, the teeth, whether plate or gum, will be relatively elongated in proportion to the increased thickness imparted to the base consequent upon the incomplete closure of the flask, and however accurately or skilfully the porcelain teeth may have been originally fitted to the vacuity in front, the artificial will be found to depart from the natural gum, while the porcelain crowns will be displaced and projected below those of the contiguous natural organs. Such displacement in the cases last referred to, however small in degree, cannot fail either to impair or destroy the value, both as respects appearance and utility, of the substitute. The method of furnishing an exit to redundant material, as usually practised, is to form a series of conduits or grooves in the surface of the plaster, extending them from the edge of the matrix to the rim of the cup. The escape of the gum will be facilitated by cutting notches at intervals around the rim of the flask, making the grooves in the plaster continuous with them, the grooves being an eighth or a fourth of an inch apart. To still more effectually prevent the intrusion of the vulcanite material between the surfaces of the opposing sections of plaster, a circular groove may be cut in the plaster within a line or two of the margins of the matrix, as is shown in the illustration, Fig. 520, into which narrow channels at short distances are made, leading from the mold; others, again, are made at wider intervals from the circular groove to the outer

margins of the flask, terminating as before in small notches formed in the rim of the cup. The two pieces when closed upon each other form a matrix. Into the grooved section of the mold, the vulcanizable substance is packed previous to being indurated. It is at this stage that the materials employed to exclude the rubber from between the teeth, and noticed in another place, are packed into the joints before the gum material

FIG. 520.



is introduced. The face of the model should also be coated with some substance which will prevent the rubber from penetrating the pores of the plaster and its adhesion to the surface of the model. Preference is given by Professor Wildman to liquid silex, as being more readily detached from the surface in finishing than the preparations mentioned. Whatever is used, it should be allowed to dry perfectly before packing. Other methods, and good ones, are to burnish a sheet of tinfoil over

the cast, or sprinkle Lycopodium or soapstone upon the surface of the cast. These latter should be brushed off with a jeweler's brush or a soft brush wheel, which will leave the surface of the model with a high polish.

Packing the Mold.—The portion of the flask containing the teeth should be first heated in an oven or furnace, or over the flame of a spirit-lamp, until the temperature of the whole is sufficient to render the rubber soft and pliable as successive portions are applied and pressed into the mold, and to retain it in that condition until the operation of packing is completed. Narrow strips of the rubber should first be worked carefully into the contracted groove underneath the platinum pins with small curved or straight-pointed spear-shaped steel instruments (Fig. 521), adding on small pieces at a time after each successive portion is thoroughly impacted, until the main groove of the matrix over the base of the teeth is partially filled. The palatal convexity

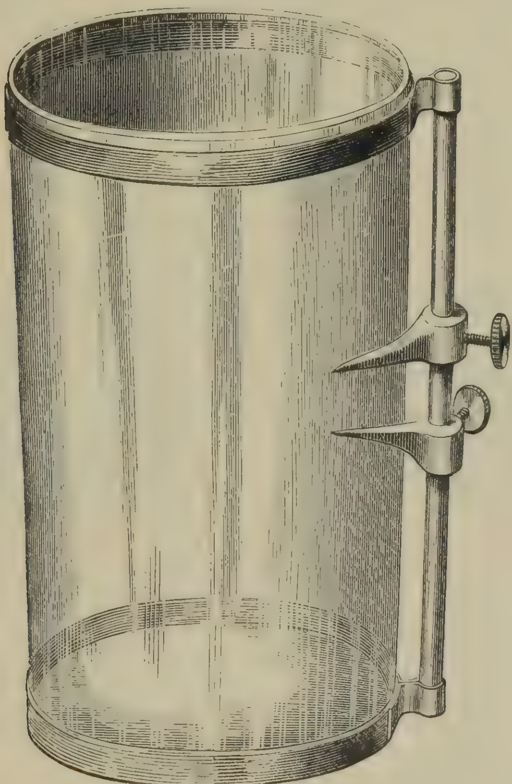
Fig. 521.

of the mold may then be covered with a single piece cut to the form of the uncovered space; a smaller piece of the same general form as the latter may then be added, giving to the central portion a double thickness of the gum-plate material, so that when the two sections of the flask are brought together the excess of gum in the center will be forced gradually to the margins of the mold, diminishing, thereby, the liability of the grooves becoming prematurely clogged with the material before the opposing sections of the flask close upon each other. Especial care should be taken in the process of packing to avoid contact of the instruments with the surface of the mold, as fragments of the broken plaster are liable to mix with the gum and render the surface of the finished work imperfect by forming small pits wherever such particles occur.

In regard to the quantity of rubber necessary to perfectly fill the matrix, experience in its use will enable the operator to esti-

mate the capacity of the mold with tolerable accuracy. Some small *excess* of rubber should always be provided. The required quantity, however, can be more certainly determined by *measurement.* A very simple instrument (Fig. 522), contrived by Dr. E. T. Starr, may be used to determine the quantity by measurement.

FIG. 522.



The vessel being partly filled with water, the lower point is adjusted and fixed with a screw to mark its height. Into this every particle of the model plate is immersed, and the rise of water indicated in the same manner by the upper point. The vessel is then emptied and well cleansed, clean water filled in to the level of the lower point, when rubber is added in sufficient

quantity to bring the surface of the water on a level with the upper point; to this is to be added the necessary excess of rubber before recommended.

Having completed the packing of the mold, the two portions of the flask are re-applied to each other in exactly their original relation, being careful that the apposition of the two is such that, when approximated, the guides attached to one division of the flask shall pass directly and without obstruction into the grooves or slots in the one opposite. With the flasks first introduced, some difficulty and uncertainty were experienced in effecting the desired closure of the flask on account of inherent defects of construction, but more recent improvements have entirely obviated this difficulty. Fig. 523 represents the Hayes flask,

FIG. 523.

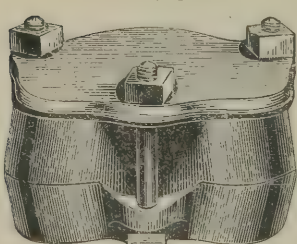
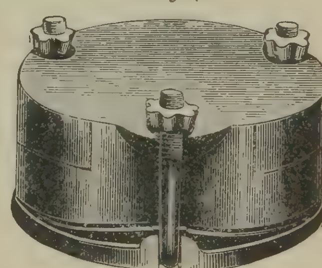


FIG. 524.

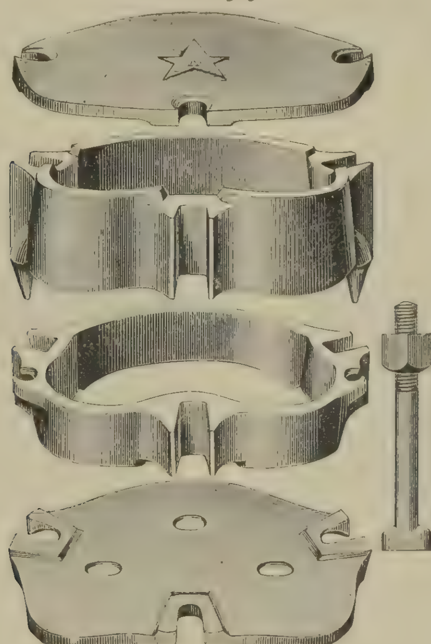


with improved clamps. The lug-joint is so constructed that the strain all comes upon the casting. The pin only serves to keep the lug in place while not in use. The several pieces all being attached together, are not liable to get lost or mislaid. The improved Whitney flask is shown in Fig. 524. The improvement in construction consists in reversing the position of the bolts, fitting the head into the hole in the lower part of the flask, and using a nut on top.

What is known as the "Starr Flask," highly commended as fulfilling very perfectly the requirements of practice, and as happily meeting some important indications, is represented in Fig. 525. Every operator of experience is familiar with the annoyance and difficulty sometimes attending a satisfactory adjustment of models of unusual depth, often of lower sets, and

partial pieces, where the porcelain teeth are secured by the surrounding plaster to the model—difficulties arising from the shallowness of the lower section of flasks as ordinarily constructed. The "Reversible Flask," invented by Dr. E. T. Starr, the different parts of which are represented in the accompanying cut, provides very perfectly for any exigency that may arise in the class of cases mentioned. The following description of this flask is taken from the *Dental Cosmos* :—

FIG. 525.



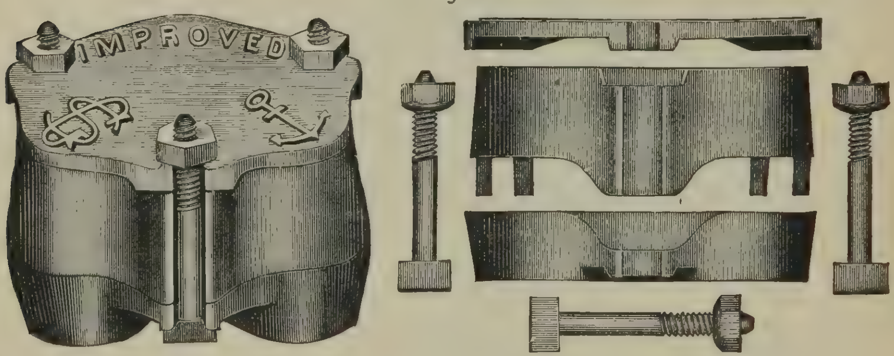
"The rings of this flask are of different widths, either of them fitting the top or bottom accurately, as may be required.

"By using the wide ring next to the bottom, an admirable flask is obtained for deep cases and partial sets, or where the artificial gum rests on the natural. The narrow ring is used next the bottom plate, for whole dentures, where the parting is at the rim of the plate. The bottom has three countersunk holes, through which the plaster runs, and, when set, holds the

accompanying ring securely to it. The fastenings of the flask are T-shaped at one end, and fit the slots in the bottom plate; and, being free at both ends, are more easily adjusted than ordinary bolts. The flask being in four pieces (two rings and two plates), the plaster is removed without the usual trouble. Fig. 525 represents the flask in sections."

The writer has, for several years, used almost exclusively, and with the greatest satisfaction, a flask constructed with detached T-shaped bolts fitting accurately into slots or grooves extending continuously from top to bottom of the flask, as represented in Fig. 526. The closure of the sections by this arrangement, with the bolts in place, is unerring, and is accomplished with

FIG. 526.



the greatest facility. It is known as the "Improved Anchor Flask," and is manufactured by Gideon Sibley, of Philadelphia.

The "Taylor Improved Flask" is represented in Fig. 527. The posterior and lateral portions of the lower section, having raised margins, gives the section at these points considerable additional depth, a modification of form especially well adapted to lower pieces. Still another useful form of flask is that devised by Dr. I. N. Broomell, and is represented in Fig. 528.

Fig. 529 represents an oblong, or "box flask," designed for exceptionally large cases, splints for fractures, artificial palates, etc.

Whatever flask is used, the entire mass of inclosed rubber

FIG. 527.

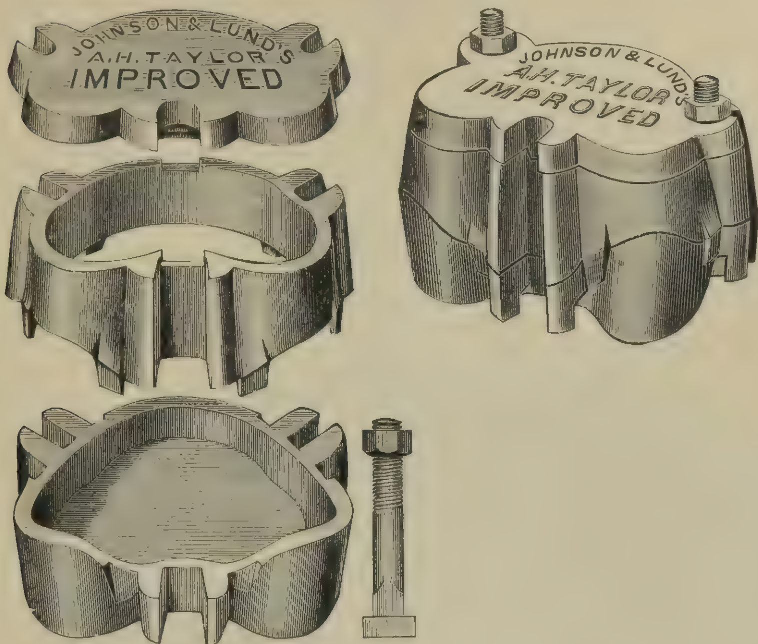
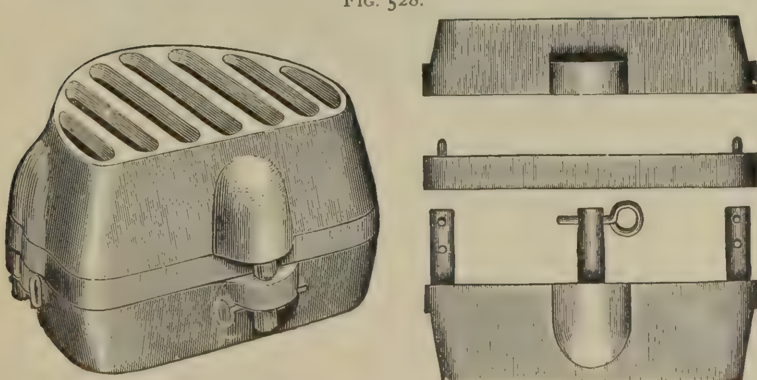


FIG. 528.



should be rendered uniformly plastic, after packing, by subjecting it to either a dry heat, such as may be obtained with a conveniently constructed sheet-iron furnace, the baking apart-

ment of an ordinary cooking stove, or any other available means by which a diffused and uniform temperature may be secured, being careful not to overheat; or, if moist heat is employed, by immersing the flask in boiling water for a time sufficient to soften the rubber. The approximation of the sections of the flask should be effected interruptedly—alternately heating the entire mass and tightening by means of the screw-bolts until all the redundant material is expelled by degrees through the outlets provided for it, and the sections of the flask close accurately upon each other.

FIG. 529.

Vulcanizing.—The process of vulcanizing or hardening the various rubber compounds employed for dental purposes is effected by subjecting them for variable periods of time to the action of heat, the substances to be acted on being confined within a chamber constructed for the purpose.

As introductory to a consideration of the usual methods and appliances employed in the process of vulcanizing, considerable space is given to the following somewhat lengthy abstract of a paper by F. Alb. Boeck, of Berlin, Germany, translated by Dr. Louis Ottofy, of Lebanon, Ill.* The discussion embodies a

Missouri Dental Journal, June and August, 1882.

somewhat exhaustive consideration of the *rationale* of the process of vulcanizing, and is introduced in this connection not only as a matter of curious scientific interest, but of practical importance in the proper treatment of a plastic material which still continues to be largely used as a base for artificial dentures. The writer says:—

"The rubber we use, as is well known, is common rubber mixed with sulphur, to which is added certain coloring materials. Of the latter I will speak later in the course of this paper. Though they may influence the hardening of the rubber indirectly, they have no other direct influence. This rubber mixed with sulphur forms our 'dental rubber.' The rubber which we obtain from the dental depots is already 'vulcanized,' as this latter simply means mixing the sulphur. We know that when it is heated it becomes hard. The circumstances under which this takes place leads us to several questions: Is it the heat, or the steam pressure, or the melting of the sulphur, which causes the change in the rubber.

"Formerly, the impression prevailed that the hardening took place from the influence of the steam. In the first vulcanizers the flask stood on a stand in the vulcanizers above the water; but as once, in 1856, the flask fell into the water, the vulcanizing took place as usual, the mistake was corrected. Later it was found that the process would take place even if the heat was passed through oil or sand, and that the same was the case with glycerin and paraffin. Certainly, under these circumstances, the time of vulcanizing was longer than when steam was used; this circumstance, at that time, however, was of no particular consequence, as it took from three to four hours to vulcanize it by steam. I will return to this difference of time later; suffice it to state here that vulcanizing can take place in the absence of steam.

"It is clear, therefore, that it is the heat alone which causes the hardening of the rubber. In order to answer the question of why this takes place, it will be necessary to turn into the domain of chemistry.

"The rubber is a vegetable product; it is the sap of certain trees, which hardens on exposure to the air. As a vegetable

product it is liable to the changes of all other vegetable substances, and all changes which it undergoes are found equally effective on other vegetable substances. From this fact it is very simple to draw conclusions for our purpose.

"Chemistry teaches that all vegetable products, such as wood, starch, the leaves and sap of plants, consist of four elements, oxygen, nitrogen, hydrogen, and carbon. In no plant, or the product of a plant, is carbon absent, and it is mostly in connection with hydrogen and oxygen, whereas nitrogen is but seldom present. From these few elements nature has produced all that earth possesses of vegetable growth, the variety and difference being sometimes only the different proportion of union of the elements, or the addition of a small amount of acids, bitter sub stances, coloring matters, or salts. Rubber consists only of the above elements, namely, $C_{16}H_7$; it belongs, therefore, to the class known as the hydrocarbons, and to that class of these in which C predominates. It is interesting to notice here that the change from the soft to the hard, as is the case with rubber, is the property of all vegetable products. We know that the change takes place by the application of heat, that hydrogen sulphid (H_2S) is formed, and that the process takes place during the exclusion of air. This process is chemically the same as takes place in the dry distillation of wood, in the changing of wood into coal, and of resin into amber. If wood is heated in the open air it burns; the same is the case with rubber, only that the latter burns slower on account of its larger percentage of C. If wood is, however, heated in the absence of air, as is the case in making illuminating gas, quite peculiar substances are eliminated from the wood, the illuminating gas, which escapes, and three substances; a watery pyroligneous acid (wood vinegar), a thick, viscid liquid (wood tar), and a solid mass (charcoal).

"The wood tar is, like the rubber, of a resinous nature; it consists of the oil of wood tar and a liquid substance, burnt resin. Both *become hard on cooling*; the former is the well-known paraffin, the latter the equally well-known pitch.

"The rubber undergoes similar changes. If it is heated while excluded from the air, as is the case in vulcanizing, there escapes (as in the case of wood, illuminating gas), the hydrogen sulphid,

and there remains a plastic, which hardens on cooling, as in the case of pitch or paraffin, and we have our hard rubber.

"If we think over this subject, it becomes clear to us why sulphur is added to the rubber. By dry distillation one or more equivalents of hydrogen separate from the mass and remain gaseous, or unite with other substances present and form a liquid, thus leaving behind a hard substance, which consists mainly of C. It is well known that the hardest substance, the diamond, is pure C. The more equivalents of H that remain, the softer is the substance, as in the following scale: coal, resin, pitch, axle grease, oil, ethereal oils, gases. The same is the case in the reversed order. If, from the soft rubber hard rubber is to be made, it is necessary to remove from it one or more equivalents of H. This is the case in dry distillation. If there was no dry distillation, if the rubber was heated under free admission of air, the C would immediately unite with the O of the air, forming carbonic acid, combustion would take place, even though it would be slow and difficult. That cannot take place when the air is excluded, the carbon remains unchanged, whereas the H finds a substance with which it is more than willing to unite at a high temperature. This substance is the S, and the union of these forms H_2S, which is well-known to us by its odor. When this union has taken place a chemical change has been accomplished, a new substance has been produced, the gas escapes, the remainder, the product of the distillation, contains less H than the raw rubber, and on cooling, like pitch, it becomes a harder substance by its containing more C than before. Hard rubber, therefore, is one step nearer to resin than soft rubber. All resins are, as is well known, involatile substances, and they possess the power to prevent other substances from becoming volatile; they are insoluble in water, and, consequently, tasteless; they are soluble in volatile oils, as turpentine oil, benzene, etc. It is known that hard rubber does not only possess these characteristics, but resembles the resins, by its easy electrification, to a remarkable degree.

"My hypothesis, therefore, leads me to the following conclusion:—

"*The hardening, or so-called vulcanizing of rubber, is the chang-*

ing of caoutchouc into a resin-resembling substance, by the process of dry distillation; that is, by the removal of one equivalent of H. *The addition of* S *serves only as a base, which is indifferent toward* C, *but unites with* H *by virtue of a strong chemical affinity existing between* H *and* S, *which form a new compound*, H_2S, *which escapes as a gas.*

"You will notice I do not agree with the opinion that the sulphur, by melting and hardening, exerts the influence required to harden the rubber. The hypothesis was laid down in some American dental journal, that just as is the case with camphor and celluloid, it is with sulphur and rubber—that is, that the sulphur is the medium which brings the particles of rubber into the plastic condition, and afterward retains them in the hardened condition.

"We know that a portion of the original composition of the rubber has disappeared, and we know that some of the sulphur and hydrogen disappear. It is natural that if more sulphur is present than can combine with one equivalent of hydrogen, the remainder is in mechanical union with the rubber. If hard rubber be heated to a degree somewhat higher than the boiling point of water, it loses its hardness. This fact might lead to the conclusion that the sulphur melts, and thus influences the hardness of the rubber. If, however, the correctness of my theory be granted—that is, that hard rubber is nothing but the resinous state of the original product—we observe that it must soften, as the melting point of the resins is about the same as that of sulphur. Furthermore, we know that sulphur hardens slowly, whereas resins become hard more rapidly, as is the case with shellac and sealing wax; the same is the case with heated hard rubber. Hard rubber, when undergoing the change from its melted condition into the hard condition, does not change the character of its molecular relation, remaining amorphous; resembling in its structural appearance molten glass. All resins, gum, glue, tar, etc., show the same characteristics. Sulphur, on the contrary, when changing from its molten condition, either crystallizes or becomes crystalline in appearance.

"I do not wish to prove anything further by this theory. It may, however, be mentioned, that if it be correct, some impor-

tant results may be accomplished. I will mention, for one, the fact that the scraps and filings of hard rubber, which are now useless and thrown away, may be made valuable and useful. Lately, a patent has been obtained by which useless vulcanized rubber may be made useful.

"Leaving this subject, we now arrive at one not less important, namely, the influence of steam pressure on vulcanization.

"It has been previously stated that vulcanized rubber may be hardened without steam. This teaches us that hardening is not produced by steam. The theory which has been discussed gives us the reason. The question arises, Why do we use steam? The answer is, steam has no direct influence in vulcanizing; it only serves, the same as oil, sand, paraffin, or glycerin, for the transmission of the heat. This takes place by use of steam, faster and with more precision and certainty than with other substances. Furthermore, it will be shown further on that for other reasons steam is the best vehicle for the purpose.

"As with oil, by using steam the heat is equally distributed and the temperature rises evenly. Changes of temperature, as is the case in dry vulcanization or over-heated steam, are also prevented. It also has the important advantage of causing the hardening to take place more rapidly. This latter fact is known to us by experience; it only remains to explain the reason why this is so.

"By the use of steam, hardening takes place in from fifteen to seventy-five minutes, according to the temperature, the quality of the rubber and its thickness; by the use of dry heat or oil the process requires from two to three hours, and the requisite degree of heat must be reached gradually. What is the reason that by use of steam and a high degree of heat it takes less time to vulcanize? It must be remembered that the higher the temperature the less time is required to vulcanize. The reason of this is clear, if we remember that, according to my theory, hardening is subservient to the escape of a certain amount of hydrogen from the rubber.

"The greater the heat, the easier is the separation of the unnatural union—as it were—of the hydrogen with the carbon of the rubber, and it also facilitates the union of this H with the S,

which is in a molten condition. This takes place in accordance with the laws of chemical affinity and relation. It is a sort of magnetic power which the sulphur exerts upon the hydrogen, and which becomes firmer and more powerful the higher the temperature. Here the steam does not take any part, as it only does the same thing that oil or sand would do, and that is to transmit the heat. There must be another reason why the use of steam permits us to increase the temperature and shorten the time. We know that we cannot do so when using sand or oil, as in that case the rubber becomes porous. If we can find the reason why the rubber becomes porous, we can ascertain the influence of the steam when used a shorter time.

"A great deal has been written and said in regard to the porousness of rubber. This takes place when the escape of the gas is retarded or prevented in certain places. This may take place when the heat was applied rapidly or unevenly, or when it was not equally distributed to all parts of the rubber. In the latter case, such parts as are more exposed to the radiating heat than others become hard much sooner, because the H escapes quicker. In the former case, that is, by rapid increase of heat, the outer surface of the rubber hardens sooner than the inner, to which the heat only reaches gradually. Rubber is, as is well known, the poorest of conductors. It is clear, therefore, that the thicker a piece is, the longer it takes it to become heated in all parts, and the more gradual must be the heating, in order that an even hardening, or rather, an even drying, of the mass may take place, so as not to produce a hardened outer rim when the inner substance is yet soft, *i. e.*, contains more H. The H, which is becoming rarefied by the increase of heat, has not the power to force itself through the hardened parts ; it, however, possesses a considerable power of expansion, which increases by the constant application of heat ; it therefore forms a cavity for itself in which the yet unhardened rubber deposits its H as long as it escapes from the rubber, and until it is free from it and becomes hard. This is a supposition which becomes more clear by future statements.

"Accordingly, in order to prevent porosity, nothing else is necessary than to heat it in such a manner that the

heat is equally distributed. This result is obtained by observing :—

"1. That the heat is equal on all surfaces, and

"2. That the heat be gradually raised and continued, according to the thickness of the plate.

"In making plates of considerable thickness, experience taught us to observe the above rules, or the strength would be lessened.

"It was mentioned before that steam, like oil or paraffin, serves simply to convey the heat. It furthermore possesses two other properties which make it more valuable than the other substances: 1. Its well known property of conducting heat. 2. Its elasticity. In consequence of its conductibility, it distributes the heat evenly; and in consequence of its elasticity, it prevents an uneven rise of its temperature, while oil, *e.g.*, will follow any change in the temperature that may be caused by the applied heat. Consequently, steam serves as a reservoir of heat, as a balance-wheel serves as a resérvoir of power; as the latter distributes the force, so does steam distribute evenly the overabundance of heat from one point where the flame is larger, or for a moment when the heat is greater it is equalized over the surface and over several minutes of time. Therefore, if the rubber exposed to it is not too thick, so that its influence can reach through the whole mass of the poorly conducting rubber, one may be certain that by the use of steam the heat exerts its influence evenly and the temperature also rises equally. There need be no fear, therefore, that one place will be harder than another, as is often the case with oil; also the temperature may be raised higher, and, consequently, less time required for the process, and no fear entertained on account of porosity.

"Another property of steam may here be considered which exerts a still greater influence than either its conductibility or elasticity, and which also hastens the process I have illustrated, chemical affinity; viz.: the magnetic—that is, the power of substances to form certain compounds.

"The steam acts like a magnet upon the sulphureted hydrogen, dissolving this gas with a great deal of alacrity, forming a solution of sulphuretted hydrogen.

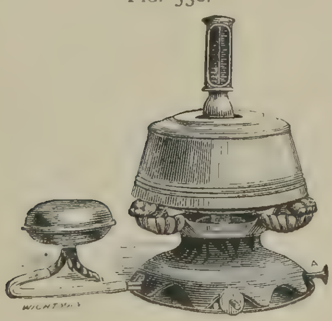
"It is true that the property of steam is contradictory to the formation of H_2S within the rubber. The hardening, in my opinion, is nothing more than dry distillation, and this is nothing more than 'slow burning by the exclusion of air.' This takes place more rapidly the better the provisions are for carrying away the products of combustion, such as carbonic acid, oxid of carbon, etc., and the same is the case in any chemical change.

"What the chimney is in the burning of wood, the steam is in vulcanization. In the latter, the product—that is, the H_2S—is readily taken up by the steam, thus furnishing the opportunity for more to be formed, and permitting the rubber to harden quickly. This is the main reason why we can vulcanize faster when using steam, than either oil or sand.

"The other properties of steam permit of raising the temperature rapidly, and by absorbing the gas which is formed, serve as a proof of the foregoing assertion, that the hardening of rubber takes place by the escape of one equivalent of H_2, and that porosity is caused by hindering the escape of this gas."

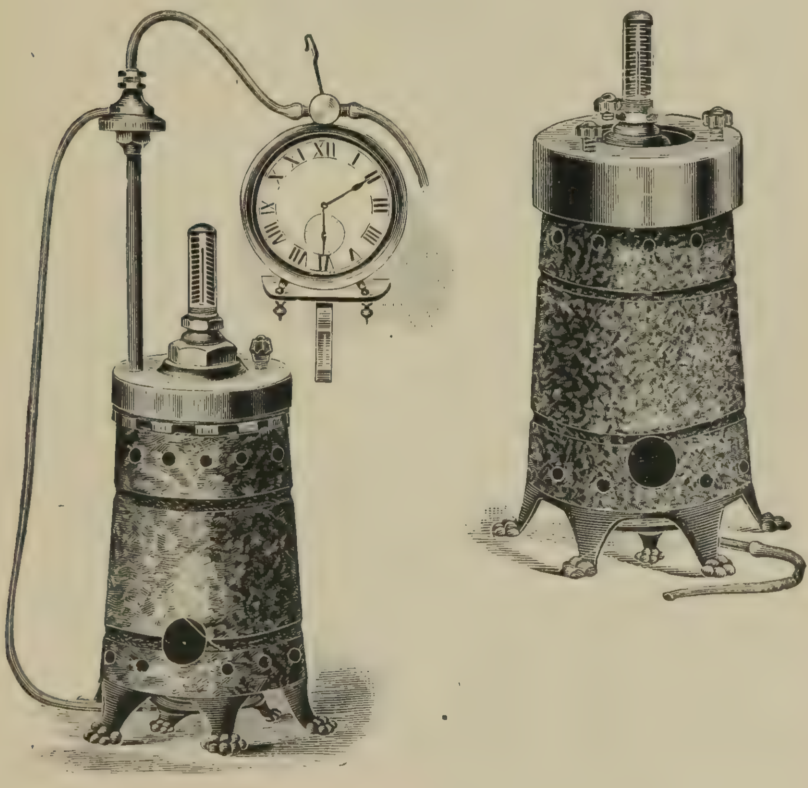
The Time and Temperature Necessary.—As solid fuel is no longer employed in vulcanizing, any description of the apparatus especially adapted to this mode of producing heat is deemed unnecessary. They have been entirely superseded by others of improved form and construction adapted to the use of either gas, alcohol, or coal-oil and its products, for heating purposes. After the lamp or burner has been lighted, it should be so regulated as to require a *half hour to raise the temperature to the vulcanizing point*, 320° F., or 120 lbs. pressure by steam gauge. This, of course, is for ordinary work; where for any reason the rubber is unusually thick the time for running it up to the vulcanizing point should be extended to one hour or more, according to the thickness of the mass, as *the heat, if run up too rapidly, will cause the rubber to become spongy or porous.*

FIG. 530.



The Hayes Vulcanizers.—Fig. 530 represents one of Dr. Hayes' Single Flask Iron-clad Ovens, convenient and compact in form, and capable, it is claimed, of vulcanizing in forty minutes at a temperature of 320°, with one ounce of alcohol. Instruments of similar construction are produced by the same

FIG. 531.



manufacturer with a larger boiler capacity for from one to three cases, Fig. 531.

The iron-clad improvement in these machines is designed as a protection from the dangers of explosion consequent upon a gradual thinning of the copper boiler from corrosion, a safeguard of great practical value and concern to those who are continually exposed to the perils of such an accident. The shell is made of

malleable iron, one-eighth of an inch thick, strong enough to resist many times the strain required, and can never be exposed to deterioration. The copper lining is made the same thickness as the copper boilers now in use, and the machine may be used with perfect safety, even when the copper has become as thin as paper; and then, when an opening has been fairly eaten through, steam will escape from between it and the iron shell, below the packing joint, giving timely notice that a new lining is required, which can be inserted at moderate expense, and render the vessel good, and safe as new.

A peculiar and important feature of these vulcanizers is in placing the thermometer bulb within a mercury bath, outside the steam-chamber, relieving it entirely from the danger of being crushed or checked by the pressure of steam, as is liable to happen when it is exposed to the steam itself, necessitating its frequent replacement.

In the accompanying illustration the Time and Gas Regulator is also shown. This regulator (the Coolidge-Lewis) is without doubt the most convenient and perfect in its action and adjustment of any yet constructed.

The pointer is so constructed that it acts as a stop by coming in contact with the inlet tube. This stop prevents the regulator from being set either by design or accident to maintain a higher temperature than the highest graduation on the base, and endangering the safety of the vulcanizer. It also requires no special adjustment after leaving the factory.

To vulcanize at any of the degrees of temperature marked on the graduated base, all that is required is to turn the milled hand-plate till the pointer is over the degree desired. This can be done either before or after lighting the gas under the vulcanizer.

It should not be forgotten when vulcanizing at a low heat to extend the time of vulcanization.

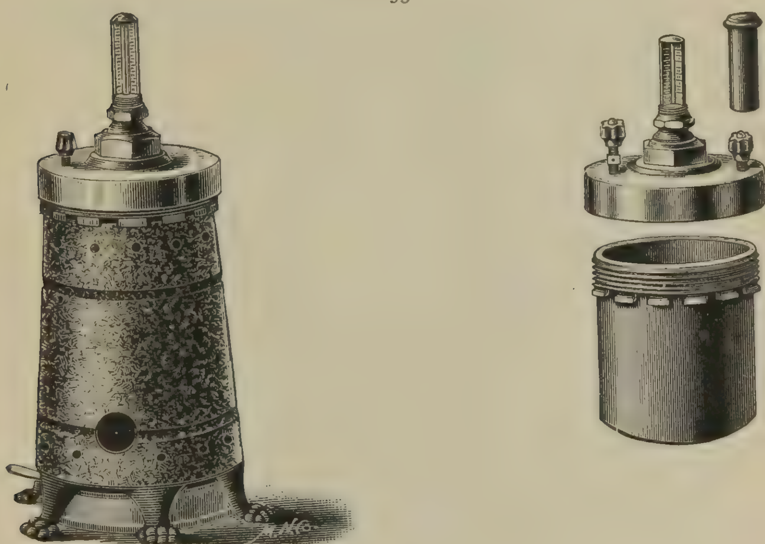
Better results are obtained by running the vulcanizer from an hour and a half to two hours—exclusive of the time of heating up—at a low heat.

This Graduated Gas Regulator is provided with a by-pass screw adjustable to different pressures of gas. The adjustment,

as it leaves the factory, is for coal gas—low pressure. If the regulator is to be used with natural gas, at a high pressure, too much gas will be passed after the proper temperature has been reached. A re-adjustment of the by-pass will then be required. This is accomplished by turning the small screw on the side of the gas chamber till the flame maintains the heat at the proper temperature. Fuller instructions accompany these regulators when sold to the profession.

The Whitney Vulcanizer.—A not less convenient, safe,

FIG. 532.



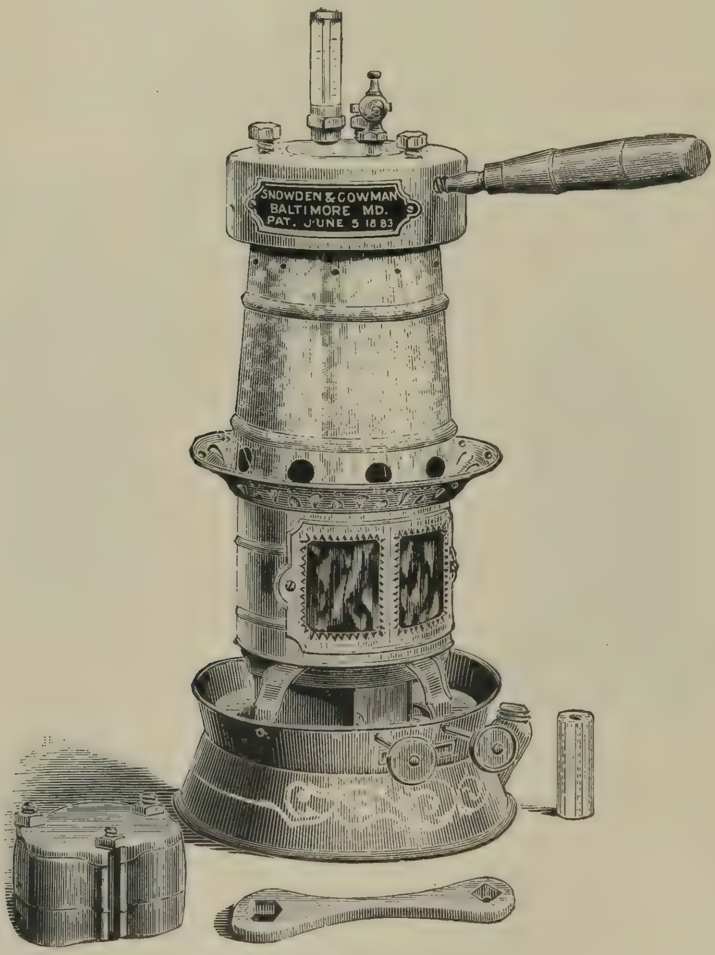
and reliable vulcanizer is that known as Dr. Whitney's, represented in Fig. 532, having a steam-chamber capacity for from one to three flasks.

The Snowden & Cowman Vulcanizer is illustrated in Fig. 533. It is an approved apparatus of more recent introduction, resembling somewhat the Hayes vulcanizer in general construction, differing somewhat in the method of fastening the cover, which, in the latter, is placed upon the packing joint and secured by a screw collar which screws over the edge of the pot, three set-screws which bear upon the cover, to make the

joint steam tight, while in the Snowden & Cowman apparatus the collar has lugs upon its interior engaging with others upon the pot, thus dispensing with the screw thread.

The Mann Vulcanizer, rigged for gas or alcohol, is shown

FIG. 533.



in Figs. 534 and 535. The same apparatus has stove attachment for the use of kerosene, and admits of the use of thermometer or steam gauge.

The facility with which this vulcanizer may be operated is one of its distinctive features. The lid, instead of being screwed on to the boiler, is fitted neatly, and rests on a shoulder formed on the casting, and is secured by a heavy steel clamping-bar and screw-bolt. One end of the bar is hinged to the side of the boiler, the outer end being slotted to receive the screw-bolt, which is hinged to the other side of the boiler. Rubber packing between the lid and the shoulder on which it rests makes the joint steam-tight. The lid is removed by unscrew-

FIG. 534.

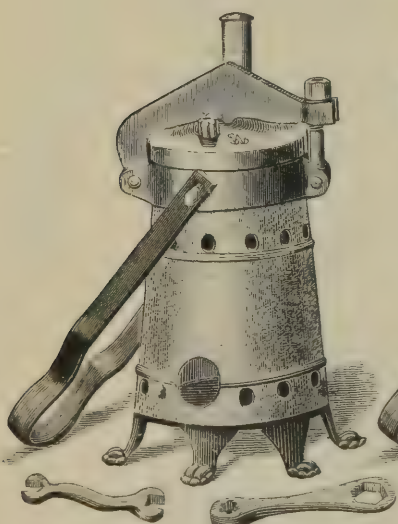
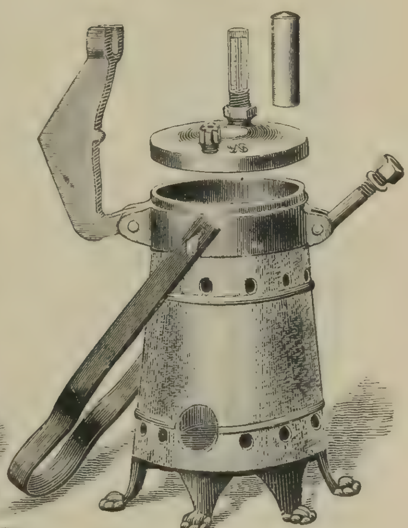


FIG. 535.

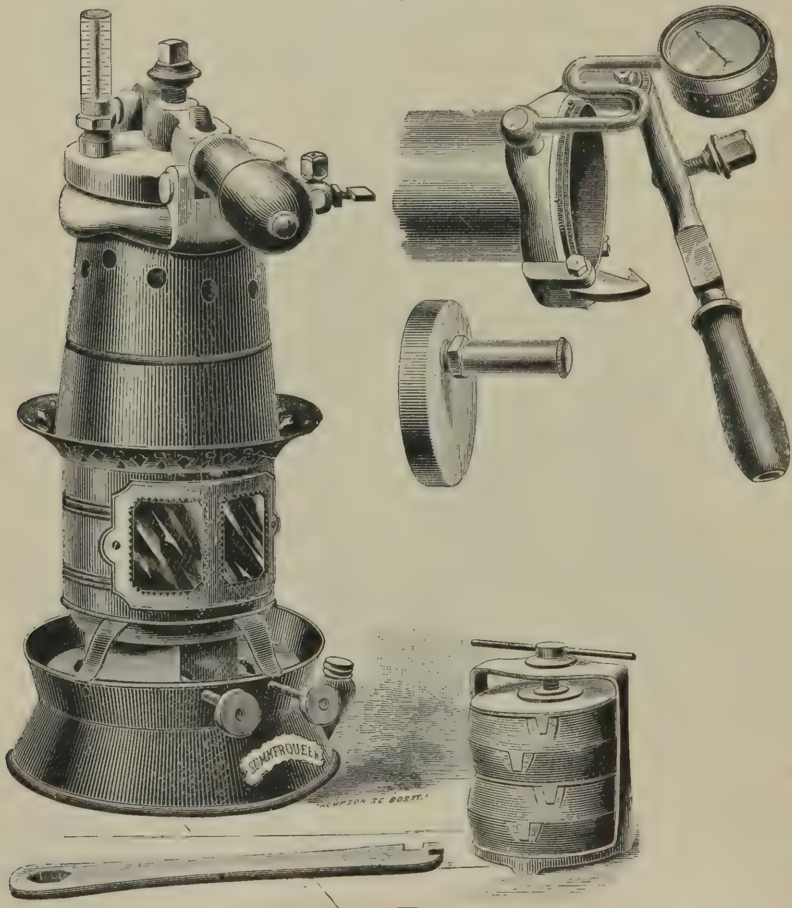


ing the nut of the screw-bolt a turn or two, when the bolt drops out of the slot and the bar is turned back, leaving the lid free to be removed. This method, while it gives as perfect a fastening as the usual plan, affords very much greater facility for opening and closing the boiler. Should it stick, by reason of the packing becoming chilled (a common occurrence with all vulcanizers), it is pried off with very much less trouble than is required when the top screws on.

Another advantage is the bail, a simple but heretofore un-

thought-of device, which greatly facilitates the handling of the vulcanizer, especially when hot. Thus the boiler can be opened for the removal of one case and the placing of another. The nut of the clamping-bolt is loosened a

FIG. 536.



little at a time, allowing the steam to escape gradually until the bolt is released, when the bar can be thrown back and the top of the boiler raised. The bail is also useful in removing the boiler from the jacket, in tightening or loosening the screw-bolt

when closing or opening the boiler, and at all times when the boiler is to be lifted. When not in use it is readily removed.

The Hood & Reynolds Vulcanizer, the several parts of which, *in situ* and detached, are exhibited in Fig. 536, involves a principle of closure similar to the one last mentioned. It is

FIG. 537.

made from a seamless copper pot which the inventors claim is four gauges thicker than any in the market.

Place the cover on the boiler with the pins corresponding with the holes in the cover; now shut down the lever and screw down the cover. To replace safety disk, unscrew nut on top of the

steam cock. Should the disk burst at any time while vulcanizing, turn the valve in, which shuts the steam off. To blow off steam, loosen screw on cover, and let steam out under it.

The Boston Vulcanizer.—This vulcanizer, manufactured by the Boston Dental Manufacturing Co., is made of the best bronze, so-called "gun-metal," and is tested at one thousand pounds hydraulic pressure. It will hold three flasks of any kind with Donham spring, and allow plenty of room for handling. The packing is molded instead of being cut in strips, and will last for years without being renewed. The cover can be screwed steam tight without the use of a wrench, the same being necessary only to open after being heated. The small quantity of water used (one gill) produces vulcanizing by steam, instead of water, thus giving better results. The bed-plate jacket, which is screwed to the bench, allows an easy and ready method of handling. It is illustrated in Fig. 537.

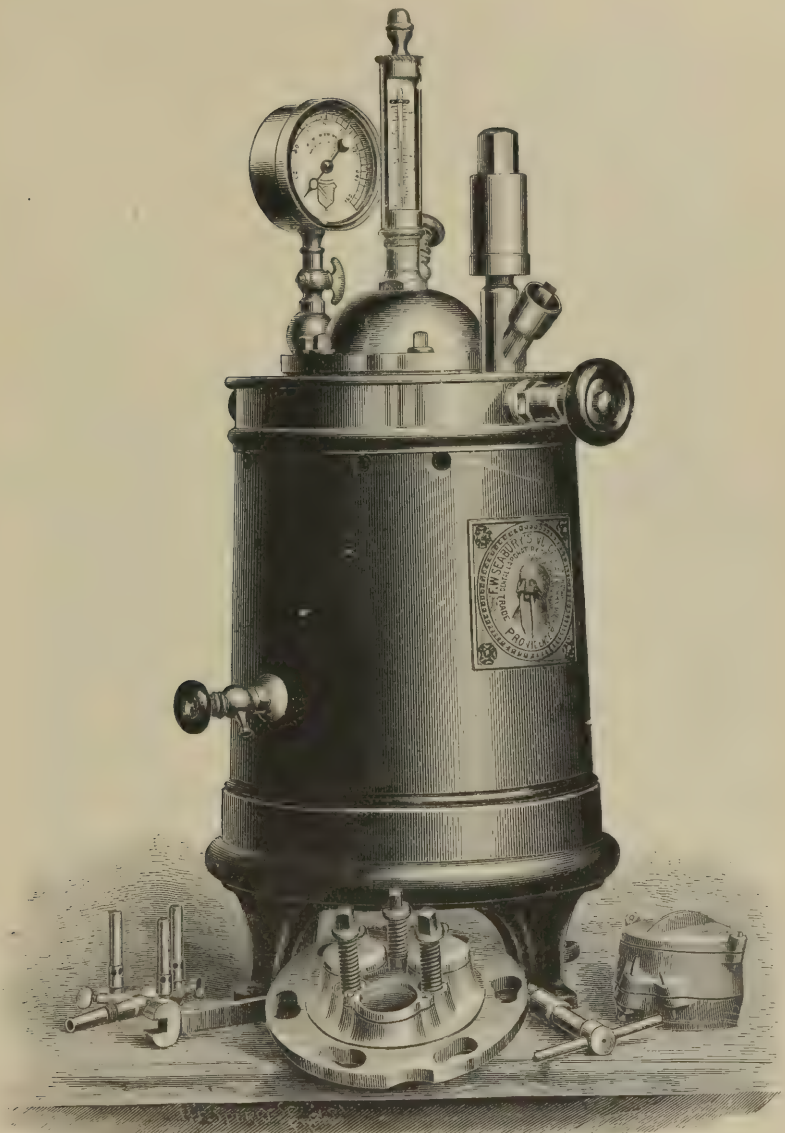
The "New Mode Heater," designed alike for vulcanizing and molding celluloid, will be described and illustrated under the head of "Celluloid Base," inasmuch as it is more commonly employed for the latter purpose, and for which it enjoys a deservedly high reputation.

The Seabury Steam Vulcanizer.—Fig. 538 represents the general body and Fig. 539 a transverse vertical section of Dr. Frederick W. Seabury's Superheated Steam Vulcanizer and Celluloid Press combined in one apparatus, which, it is claimed, will enable the intelligent dentist who does not wish to be restricted to the use of one plastic material to accomplish results never before attained. Rubber and celluloid can be manufactured with this apparatus in less than half the time usually required, and a perfect product assured every time. Both rubber and celluloid come out of the vulcanizer finished.

Cases may be removed from the oven and others inserted at any time during the process of vulcanization with a delay not to exceed five minutes, which is a great saving of time, especially with repair work. The apparatus is thus described:—

"In the accompanying drawing, Fig. 539, No. 1 illustrates a transverse vertical section of the vulcanizer with dental flasks in position.

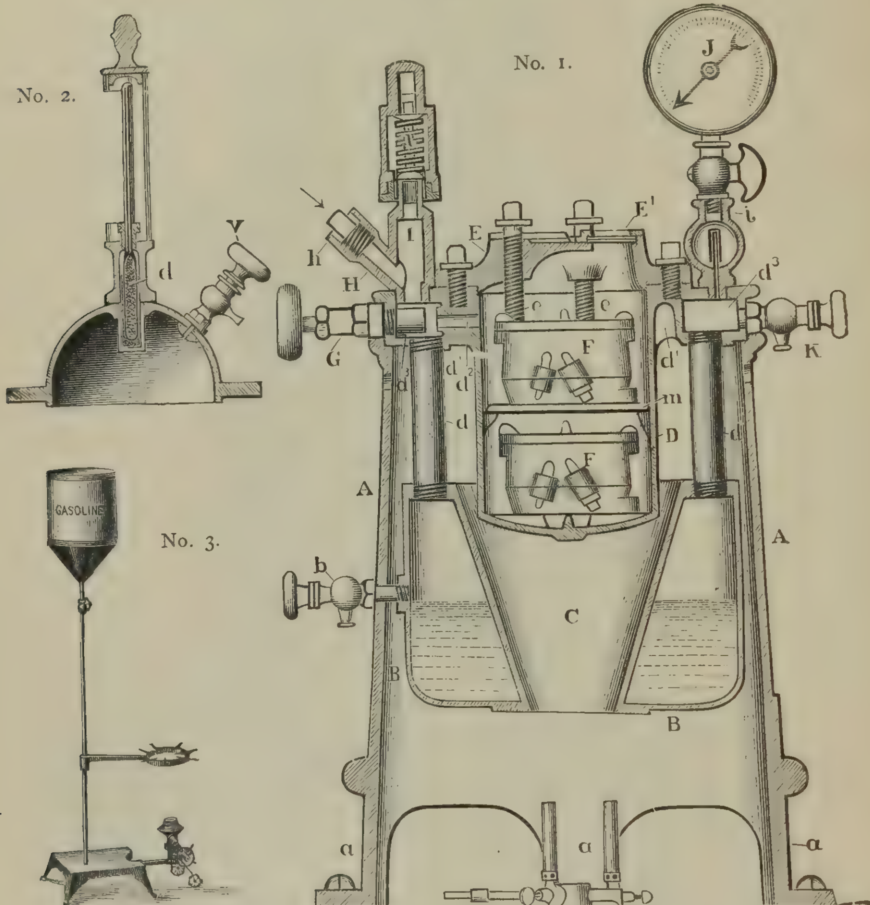
Fig. 538.



"In the said drawing, A designates the hollow body of the vulcanizer, which is supported on the legs, *a*. Within this body

is placed the boiler, B, which is formed with the central inverted truncated conical flue, C. The boiler and flue are supported by the tubes, *d*, which are connected at one end to the top of the boiler and at the other end to the chamber, d^3.

FIG. 539.



"D designates the oven, the lower end or base of which extends somewhat downward into the upper end of the flue, C.

"The upper end of the oven is formed with lateral flanges d^1, which rest upon the top of the case or body, A, and thus

support the oven in position, and also form the top of the vulcanizer.

" E designates the pressure cover of the oven, which is secured in position by bolts, as shown.

" *e e* designate presser-screws, which work through square threaded sockets in the cover and press upon the flask, F, in the oven supported upon the disk, *m*.

" E^1 designates two lids, which are pivoted upon the cover in such manner as to be readily removed, and by uncovering apertures in the cover permit visual access to the interior of the oven.

" G designates a valve, which is seated in the flange, d^1, of the oven so as to close the channel, d^2, leading from the pipe, *d*, to the interior of the oven.

" H designates a spout. The outer end of it is tightly closed by the cap, *h*, which leads into the tube, I, entering the chamber, d^3, from above. The purpose of this spout is to convey water to the boiler, B.

" *i* designates a pop safety-valve, which is seated on the upper end of the tube, I. J designates a steam-gauge connected by the siphon cock, *j*, to the chamber, d^3, into which the tube, *d*, opens.

" K designates a test-cock communicating with the chamber, d^3, and *b* designates a similar cock, communicating with the boiler, B, on the water level.

" In using this vulcanizer a gas or gasoline burner is set beneath the boiler, B, and the valve, G, is closed ; but the test-cock, K, is not closed until the escaping steam shows that all of the air is out of the boiler. The heat from the burner will ascend through the flue, C, and will act directly upon the bottom and sides of the oven, thus heating the oven and water which has been previously placed in the boiler, at the same time or separately.

" Fig. 2 illustrates a vertical section of the solid cover which is used at all times, except when closing the flask, and occupies the same position on the vulcanizer as the presser-cover, E. It is provided with a very sensitive thermometer, immersed in a mercury bath, *d*, which projects into the oven, D, and a test-cock, *v*, used to let the air out of the oven before vulcanizing and to blow the steam out through after vulcanizing.

"The bar-wrench is to be used on the cover bolts only, and must never be used on the presser-screws, *c c*, for which the T-wrench is provided.

"**To Adjust the Vulcanizer for Use.**—Open the test-cocks, *b* and *k*, remove the cap, *h*, pour clean water into the spout, H, until it escapes through the test-cock, *b*. Replace the cap, *h*, turn it to place with the fingers. If it should leak when the steam is up, tighten it very gently with the T-wrench. Close the test-cock, *b*, after the excess of water has run out.

"Place the gas or gasoline burner so it will heat the oven and boiler at the same time when you wish to vulcanize. One burner may be used under the boiler, the other in the flue.

"For celluloid, place the burner in the center of the flue, elevate it, if necessary, on a box, that as little steam as possible may be generated in the boiler. The pressure of coal gas varies in different places; a little judgment is necessary to vary these instructions to suit each place. It takes less than thirty minutes with cold water, and less time still with hot water, to get 120 pounds pressure of steam. When steam is up, it requires very little heat to keep it.

"The water should be renewed every morning the first thing, or some time the pressure will decrease apparently without any cause.

"Close the test-cock, *k*, when steam escapes, and not until then. When the pressure reaches 120 pounds the pop-valve, *i*, will blow, at first too freely; a gentle tap on top will seat it.

"The valve, G, is packed with asbestos; a piece is sent with each machine. If the packing leaks, tighten the screw gently. When the screw reaches its seat, turn it back, oil some asbestos, make two or three turns around the stem, and press it in so that the screw will catch. Turn this screw very gently, or you will bulge the barrel. The asbestos will wear one year, to my knowledge, and look as fresh as new.

"When operating the machine in vulcanizing, the valve, G, and the test-cock, *v*, should be opened gradually and slowly. By opening the valve, G, quickly, the rushing steam will siphon water from the boiler into the oven. When vulcanizing, there is 115 pounds pressure inside the flask as well as in the oven. By in-

stantly turning the test-cock, *v*, wide open, the pressure is removed from the outside of the flask, and the pressure then comes from the inside, which it is least able to withstand.

"On the inside of the oven, midway from top to bottom, are four brackets to suspend the disk, M. On the bottom side of this disk are two small projections which fit between the brackets under the steam-gauge, and thereby keep the disk stationary. On the upper side of the disk, above the small projections, are two large projections placed so as to receive the square projection on the broad side of nowel; it holds the flask when under pressure directly beneath the three presser-screws. When it is in the right position, the lock-pins of the flask will come directly under the holes, EE, in the presser-cover, through which the pins are driven home in locking. On the bottom side of this disk, in the center, is a groove cut to receive the ridge of the flask placed on the bottom to keep warm while molding celluloid or rubber in the other flask. When drying out or heating up the investments, the disk is left out of the oven. When heating up celluloid investments, put the flask in bottom side, or nowel, up, because, there being more plaster in the cope, it requires more heat than the nowel with the metal die. In rubber, rubber and celluloid, and gold and celluloid, put the flask in bottom side down. The flask being in position, put on the presser-cover—the small curve in the circumference fits the siphon bulb,—with the bar-wrench tighten the cover bolts by giving each a half-turn in succession until the cover is seated, then with the T-wrench turn the presser-screws gently. The bar-wrench must never be used on the presser-screws. The presser-cover is only used when molding. For drying out, heating up, and vulcanizing, use the *solid cover*. Place the solid cover in position, first see that the ground joint is perfectly clean, tighten the bolts by giving each a half-turn successively; *the bolts must go down evenly or the joint will leak*. Coat the ground joint occasionally with bar-soap.

"Before putting the flask into the oven to mold, always insert the lock-pins into the holes in the cope, then, when the flask is closed, they can be easily driven down."

Evans' New Vulcanizer and Celluloid Apparatus.—Figs.

540 and 541 represent Dr. W. W. Evans' New Vulcanizer and Celluloid Apparatus combined, which is claimed to possess superior qualities for vulcanizing rubber and molding celluloid and zylonite.

Fig. 540 shows front elevation with top attached and tools needed in the working of this apparatus, which is thus described:—

"Fig. 541 illustrates a transverse vertical section with one flask in position. A is a light casing, B the boiler, composed of

FIG. 540.

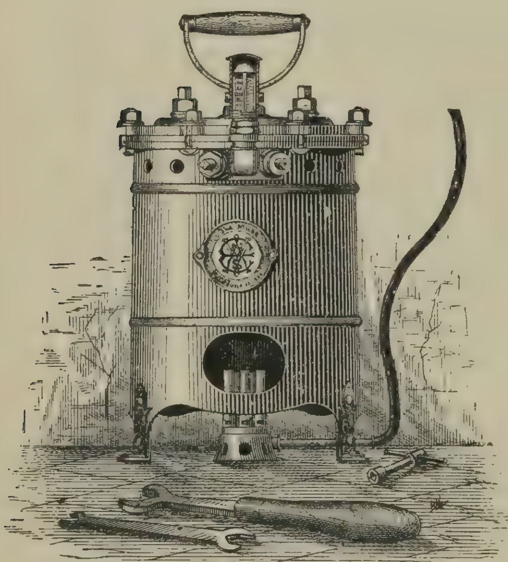
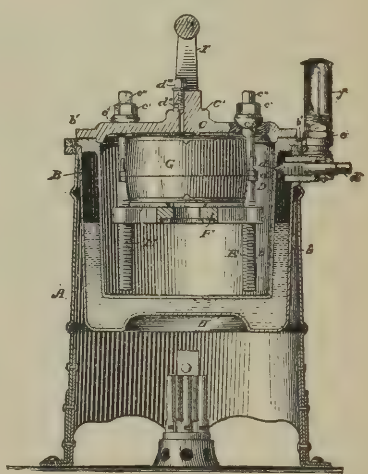


FIG. 541.



two separate cups, *b b*, united concentrically by screws, b^1, to form a water and steam space. The bottom of the boiler, A, is partly concave, to facilitate ebullition and keep the steam in a state of agitation. D illustrates the oven composed of the inner cups, *b*, having a cover. C is an inlet for steam, *d*, through the cup, *b*, from the boiler, and an exit for steam through the cover, d^2, both openings being controlled by valves, d^1 and d^3. E E represent the bolts with spherical heads at *c*, the point of contact with the cover, C, which has a corresponding

socket to receive it, thus making a steam-tight joint. The top of the head, c^2, is made to fit the T-wrench, that also fits the different valves. To gain more pressure than is usually required, an additional sexangular portion, c^1, has been made, whereby any amount of pressure can be exerted. The lower portion of the bolt is threaded for one-half its distance, and screws into or through the platen, F, which is drawn toward the top by turning the bolts to the right, thus closing the flasks, G, with facility and without any strain upon the boiler. *f* is the thermometer, on either side of which are valves, one connecting the boiler with the oven; the other a conical safety-valve, so arranged that the steam in the boiler can never go higher than the point at which the safety-valve is set. I is a handle to remove the top. Two large flasks may be used at a time, and it is claimed that it will readily stand from 250 to 300 pounds pressure. It is also claimed that rubber vulcanized in this apparatus is much more elastic, denser, and tougher, and retains its color better than by other processes, and that it will not shrink from the teeth, and can be vulcanized in thicker masses without becoming porous. For celluloid and zylonite, better results, shorter time of molding (one hour and a half), and no lost steam from the boiler, are claimed."

Whatever form of water-bath vulcanizing apparatus is used, the flasks are introduced, and sufficient water poured in to cover them. If the flasks are hot when placed in the boiler, water of nearly the same temperature should be added to avoid fracturing the teeth by too sudden cooling. Before screwing on the cap, the rubber packing should be dusted with whiting or pulverized soapstone, to prevent adhesion. As it is very important to secure a steam-tight joint, the packing should be uniform, firm, and securely fixed. The webbed rubber is the best for the purpose. In arranging a new packing, cleanse well the groove in the boiler which receives the rim of the cap, and fit the packing accurately. Before screwing on the top, dust the surface of the packing as before recommended, and as the heat rises tighten the screw from time to time until the rubber no longer yields. If the latter precaution is not observed, the packing is either liable to blow out or the joint may leak.

To insure uniform results, it is necessary that there should be absolutely no leakage.

When the flasks are properly secured within the steam-chamber, heat is applied and continued until the requisite induration of the gum is affected. The time and degrees of heat necessary to effect this result differ somewhat with the rubber compounds and kind of vulcanizer employed. The heat should be raised gradually until the thermometer indicates the proper vulcanizing temperature, when the flame should be lowered, and the heat maintained at this point until vulcanization is completed. In all cases it is best to raise the heat slowly until it reaches 320°, which temperature should not be attained in less than from one-half to three-quarters of an hour. Where there is any considerable or unusual body of rubber, the time taken to raise the heat to that point should be extended to one hour or longer, for if the mass is heated too rapidly, porosity or sponginess of the thicker portions of the rubber will almost certainly ensue. This result would seem to be due to the energetic evolution of sulphureted hydrogen gas under a quick heat, the proper elimination of which is checked, and the gas confined within the body of the mass by a too rapid surface-vulcanization of the rubber. The evolution of this gas is demonstrated by Prof. Wildman in the following experiment:—

"To ascertain if sulphureted hydrogen is given off during vulcanization, a bulb was blown at the end of a glass tube; this was filled with red rubber; the tube was then drawn out very small from immediately above the bulb, and curved so that the small part when the bulb was in the paraffin bath could be inserted into a vessel beside it.

"The bulb was then placed in a paraffin bath, and the curved end of the tube inserted in a vessel containing a solution of acetate of lead. The heat was raised to 320° F., and retained at that point for one hour and a quarter.

"The mean result of several experiments conducted in this manner was, that during the first thirty or forty minutes after the heat had attained to 320°, bubbles of sulphureted hydrogen came over at short intervals, and at the expiration of this time it was evolved in a continuous stream, which continued for a

few minutes, causing a copious precipitate of sulphid of lead. After this, until the expiration of the hour and a quarter, the gas was only given off sparingly at intervals. This experiment gives us ocular demonstration that this gas is evolved during vulcanization, and in large quantities, and conclusively shows that in thick pieces especially the heat should be slowly raised, and the rubber should be under strong pressure to insure a successful result."

When the American Hard Rubber Company's red rubber is used, the heat should be maintained at 320° for about one hour and ten or twenty minutes. Vulcanization may be effected at a lower heat, but the time must be proportionally extended; or a higher heat being employed, a less time will be required to vulcanize. Care should be taken, however, not to overheat, as the rubber is thereby rendered dark and brittle, and the important property of elasticity impaired. The time and degrees of heat mentioned, therefore, may be regarded as the safest, and as yielding the best results, though with other rubber compounds, and the use of modified forms of vulcanizers, corresponding differences in time and temperature may be required, and which can only be accurately determined by vulcanizing test-pieces of rubber.

In this connection the reader's attention is called to some practical observations on the subject of steam pressure in vulcanizing, and the reliability of thermometers as indicators of heat, and which acquire additional interest if it be true, as alleged, that many of the vulcanizers in use by dentists are insecure by reason of inherent defects of construction or faultiness in the modes of indicating the elastic force of steam. In commenting on this subject the late Prof. Wildman observes:—*

"As high steam is used in vulcanizing, it is important that the operator should be conversant with the nature of the agent which he employs to accomplish this end. It is perfectly safe; but the following will show him that it must be used with discretion and judgment. Numerous experiments have been made by scientific men to ascertain the elastic force of steam at differ-

* "Instructions in Vulcanite," p. 26.

ent temperatures. The results of their investigations are not uniform, although they all agree in showing the immense force exerted by this agent at high temperatures. Haswell's tables are looked upon as good authority. The results of the investigations of the Franklin Institute Committee, in the higher degrees, give a greater elastic force than the table below quoted. I shall, however, quote the results of the experiments of the commission of the French Academy, appointed by the French government to investigate this subject, for the reasons that, from the manner in which they were conducted, they are probably as reliable as any, and that they are extended to a more elevated temperature than the others.

Elasticity of steam, taking atmospheric pressure as unity.	Temperature F.	Pressure, per square inch, pounds.
1	212°	14.7
1½	233.96°	22.05
2	250.52°	29.4
2½	263.84°	36.75
3	275.18°	44.1
3½	285.08°	51.45
4	293.72°	58.8
4½	300.28°	66.15
5	307.05°	73.5
5½	314.24°	80.85
6	320.36°	88.2
6½	326.26°	95.55
7	331.70°	102.9
7½	336.86°	110.85
8	341.78°	117.6
9	350.78°	132.3
10	358.88°	147
11	366.85°	161.7
12	374.00°	176.4
13	380.66°	191.1
14	386.94°	205.8
15	392.86°	220.5
16	398.48°	235.2
17	403.82°	249.9
18	408.92°	264.6
19	413.78°	279.3
20	418.46°	294

"I would here call the attention of those using high steam to

an important consideration. In raising steam, *the ratio of increase of pressure or elastic force is far greater than that of the increase of temperature.*

"By referring to the above table, commencing at 212° and taking steps as near 50° as is given in the ascending scale, we find this exemplified. Thus:—

Increase of temperature.	Increase of force per square inch.	Giving a force per square inch.
From 212° to 263.84° = 51.85°	22.05 lbs.	36.75 lbs.
" 263.84 to 314.24° = 50.40°	44.10 lbs.	80.85 lbs.
" 314.24 to 366.85° = 52.61°	80.85 lbs.	161.85 lbs.
" 366.85 to 418.46° = 51.61°	132.15 lbs.	294 lbs.

"This comparison shows clearly how rapidly the pressure increases at high temperatures, and warns the operator that a strong instrument combined with care and judgment in its treatment are indispensable to safety. Besides the rapid increase of pressure, it must be borne in mind that at high temperatures, copper, of which the boiler is composed, becomes weakened, and in a measure loses its power to resist this great imprisoned force. Copper, in passing from 212° to 230° F., loses about one-tenth of its strength, and at 550 it has lost one-fourth of its tenacity."

In a paper read before the Massachusetts Dental Association, January, 1865, Dr. A. Lawrence affirms that: "Most vulcanizers are now made of sheet copper one-sixteenth of an inch in thickness, and, agreeably to the foregoing facts, have a tensile strength of 1875 pounds; and one four inches in diameter will not sustain a pressure of more than 150 pounds per square inch, or a temperature of 363°.

"Let us next ascertain what force of steam is exerted upon the boiler within a short range of temperatures. We find by the tables of Haswell, King, and others, that at 320° the pressure is 85 pounds; at 324°, 90 pounds; at 328°, 95 pounds; and at 332° it is 100 pounds per square inch. These figures I have verified by a steam-gauge connected with my own vulcanizer, and which I now use in preference to a thermometer, as I consider it more convenient, safer, and less liable to accidents.

"Practical engineers concur in the opinion that a force of not

over one-half the sustaining capacity of the boiler can be safely applied."

Immediately connected with the process of vulcanizing is the question of the reliability of thermometers as *indicators* of heat, or steam pressure. Dr. Lawrence, commenting on this subject, says: "Suppose the bulb of the thermometer gets slightly fractured, and, the accident not being discovered, the vulcanizer is put to use, what then?

"If the damage is slight, the mercury may still be made to rise in the tube at high temperatures, but will not truly indicate the full heat or force within. Some time ago I had some difficulty in producing a desirable shade in my vulcanite work; it was too dark, as is the case when overheated, and I came to the conclusion that the gum had deteriorated in quality. Other samples of gum were tried, and at varying lengths of time, yet with the same result.

"No defect could be discovered in the thermometer by the naked eye, but a microscope revealed a slight crack in the bulb, and the mystery was solved. But what force of steam was produced during these almost despondent trials?

"Although my vulcanizer would safely bear a pressure of 100 pounds per square inch, I concluded to use a steam-gauge for the future, and now feel a security in its use positively refreshing."

The unreliability of thermometers in connection with vulcanizers has been recognized by many in the profession who have testified to their uncertainty and insecurity as a means of determining with exactness at all times the amount of steam pressure employed in the process of vulcanizing at a high heat.

The *steam-gauge* (Fig. 542) spoken of by Dr. L. seems very perfectly to fulfil the requirements of the dentist, and may justly claim favorable consideration from the commendation bestowed upon it by the distinguished gentleman who has brought it to the notice of the profession. The following is the author's own account of the instrument: "The gauge most suitable for the purpose in question somewhat resembles a small, circular clock, is about six inches in diameter, and marked to register one hundred and forty or one hundred and eighty pounds pressure,

with pound dots near the outer circle of the dial. A pointer indicates the force which moves it.

"This size is better than a smaller one, because the spring inside, not being crowded to its utmost capacity in vulcanizing, will, of course, retain its working integrity longer; in fact, as long as any dentist now living will be personally interested in the matter. The price of such a gauge, at this time, is $18; and though, unquestionably, more expensive ones can be made, they are no more reliable, the difference consisting in mere 'outward show and adorning.' They can be used with all vulcanizers generating steam, connecting by means of three or four feet, or as much more as may be convenient, of small pipe having a U-shaped bend, or a single coil near and under the gauge to receive the condensed steam, as water alone should enter this instrument.

"The following table exhibits a range of pressure sufficient for vulcanizing purposes, with the temperature necessary to produce the same:—

Pressure in lbs.	Temperature.	Pressure in lbs.	Temperature.	Pressure in lbs.	Temperature.	Pressure in lbs.	Temperature.
60	295°	69	305°	78	314°	95	328°
61	296°	70	306°	79	314°	100	332°
62	298°	71	307°	80	315°	105	335°
63	299°	72	308°	81	316°	110	339°
64	300°	73	309°	82	317°	115	342°
65	301°	74	310°	83	318°	120	345°
66	302°	75	311°	84	319°	125	349°
67	303°	76	312°	85	320°	130	352°
68	304°	77	313°	90	324°		

"It will readily be seen by the above that a pressure of sixty pounds requires a temperature of 295° by Fahrenheit's scale to produce it, and eighty-five pounds 320°, at which latter pressure I vulcanize, running one hour, and with the most satisfactory results.

"The manner of putting up and using the gauge is very simple. All that is required is to secure it, by screws passing through the flange on the back, in some conspicuous and convenient place, attach a pipe and carry it down ten or twelve inches, give it a bend or curve upward about half its length, or

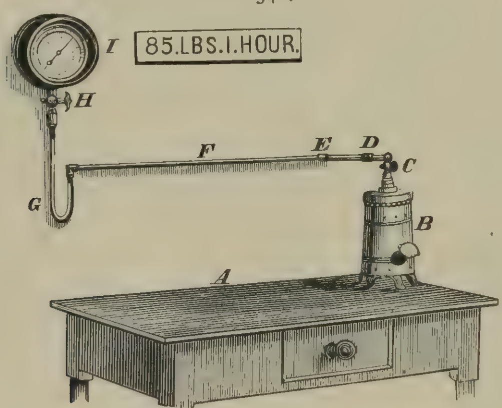
five or six inches, thence at right angles or otherwise, and in any convenient length not less than three feet, to the vulcanizer.

"The annexed cut (Fig. 542) is from a photograph of a Whitney vulcanizer with the gauge attached, but is by no means the only arrangement which can be made, as, in some cases, convenience may require more pipe or a different distribution.

"A, table or work-bench; B, vulcanizer; C, side outlet pendant cock screwed on in place of the thermometer scale; D, coupling-joint; E, angle in the pipe; F, iron pipe, three-sixteenths inside; G, U-shaped curve, five or six inches in depth; H, cock to the gauge; I, gauge.

"The fitting, putting up, and arranging the entire apparatus

FIG. 542.



can be done in an hour's time by any gas-fitter, or to those residing away from cities or towns where such mechanics are employed, can be furnished to order by them, or by parties furnishing the gauge.

"All the joints, from the vulcanizer to the gauge, except the coupling, should be 'leaded' with very thick lead paint, and screwed together steam-tight.

"In using the apparatus, the cocks, C and H, must be turned straight with the pipe, for if shut off at either point, the gauge cannot be acted upon by the steam. I generally heat the water in the vulcanizer nearly or quite to the boiling point, and let off

the heated air by turning, or allowing to remain open, the cock, C, then connect at the coupling, D, turning the nut tight with a wrench.

"So soon as steam begins to form, it is condensed by contact with the cold part of the pipe, and falls into and fills the curve or coil with water, which is then forced into the gauge with a power indicated by the pointer on the dial. The pipe should descend a trifle from the angle, E, to the commencement of the curve, to facilitate the passage of the condensed steam to that point.

"Although vulcanizing one hour at eighty-five pounds affords results satisfactory to me, others may prefer a different time with more or less heat.

"The table will be found a guide in such cases.

"When the time is up, discontinue the fire, and shut off the steam by turning the cock, C. Turn the cock, H, in the same manner, to prevent a too sudden reverse movement of the machinery of the gauge, the pressure on which should be gradually relieved at any convenient time.

"Now disconnect by unscrewing the coupling and dispose of the steam in the vulcanizer by blowing off, or any other means preferred. Further remarks would seem unnecessary to a full understanding of the subject. Having used the gauge almost every day for about six months, I am fully satisfied that it is a decided improvement in vulcanizing, and no reasonable sum would induce me to substitute the thermometer."

Another appliance, which, in important respects, is an improvement on the steam-gauge last considered, is illustrated and referred to on page 535.

This device was invented by Dr. J. B. Coolidge, of Boston, about the year 1871. A number of them were made and sold at that time, and are to-day in good condition. It is operated by the pressure of steam upon a thin metal disk, which, yielding to the pressure, closes a valve which controls the flow of gas to the burner under the vulcanizer. Extensive experiments have been made to procure a metal for the disk which would not lose its elasticity by use, nor give way from the effects of corrosion, and the present improved regulator is offered to the dental pro-

fession with the assurance that it will be found to be accurate, serviceable, and durable.

The time regulator is of new design. In this, as in the gas regulator, the use of rubber in any form, excepting as connecting tubing, has been entirely discarded, as experience has proved that substance to be very prone to deterioration from a variety of causes. It has a metallic valve, which is gas-tight, whether it be open or closed, and the operating screw being protected from the action of the gas, the valve will be found to operate with ease and certainty. The timing device is operated by the minute arbor of the clock, instead of the hour arbor, as is usually the case; it is capable of very delicate adjustment as to time, its variation being limited by seconds instead of minutes.

The gas regulator is a better means of maintaining a regular heat than a thermometer, for the reason that as it acts by the steam pressure its movement is positive, and it can be depended upon to act at the desired point after it is once properly set. Before the thermometer can act, it has to receive a certain amount of heat, and the rapidity with which this will be received depends upon the conductivity of the parts between the flame and the thermometer. There are several conditions which will operate to vary and retard the action of the thermometer.

The following experiment will illustrate the comparative operation of the two devices: "Let the vulcanizer be closed with, say, two inches of water in it, and heat applied. The regulator will turn down the gas, when the thermometer registers somewhere in the neighborhood of 300°. If the screw cap of the safety disk is now loosened, and steam allowed to escape for one minute, and the screw cap then tightened, the thermometer will in a few minutes be found to register 320°.

"The reason of this is that as air conducts heat very imperfectly, its mixture with the steam interferes with its conductivity and with the indication of the temperature by the thermometer; but after the air has been allowed to escape, there is an atmosphere of steam above the water in the vulcanizer, which must be of the pressure due to its temperature throughout its whole extent."

Removing the Flask after Vulcanizing.—When the pro-

cess of vulcanizing has been conducted a sufficient length of time, the flame is turned off and the steam discharged through the safety-valve, if the vulcanizer is provided with one; or the lower half of the boiler may be placed in cold water until the contents are cooled down to about 200°. When time will permit, however, it is better to let the vulcanizer cool gradually. The top is then taken off and the flasks removed. The latter should always be allowed to cool gradually, as the immersion of the flask, while hot, in cold water will endanger the porcelain teeth by a too sudden change of temperature. Neither should the flask be opened while hot, for the plate, being pliable when heated, would be liable to suffer some change of form in forcing the sections of the flask apart, or in removing the piece after separation of the flask. When the plate is removed from the flask, detach carefully all adhering plaster with a pointed knife, and cleanse well by washing with a stiff brush.

The Finishing Process.—The rougher and more redundant portions of the rubber are first removed with coarse files or rasps, following with those of a finer cut (Fig. 543) or lathe burs (Fig. 545), until all parts of the piece accessible to such instruments are reduced to nearly the thickness required. The excess of material on the lingual side of the plate and other points not admitting of the use of the file is removed with scrapers of various forms, some of which are shown in Fig. 544. After nearly the desired thickness is thus obtained, and the surface rendered somewhat smooth and uniform, a still further reduction is obtained with the use of sand-paper, using first the coarser and finishing with the finer numbers. The final polish is then given to the surface, first with the use of finely pulverized pumice-stone, and afterward with either prepared chalk or whiting. The best method of applying the pumice is with flat, circular pieces of cork of various sizes, which may be readily formed by attaching them to the lathe and reducing them to the proper size and shape with a file while revolving. The chalk or whiting may be applied upon a cotton or ordinary brush wheel. In the use of the polishing materials, the latter should be kept constantly and freely saturated with cold water throughout the operation.

Fig. 543.

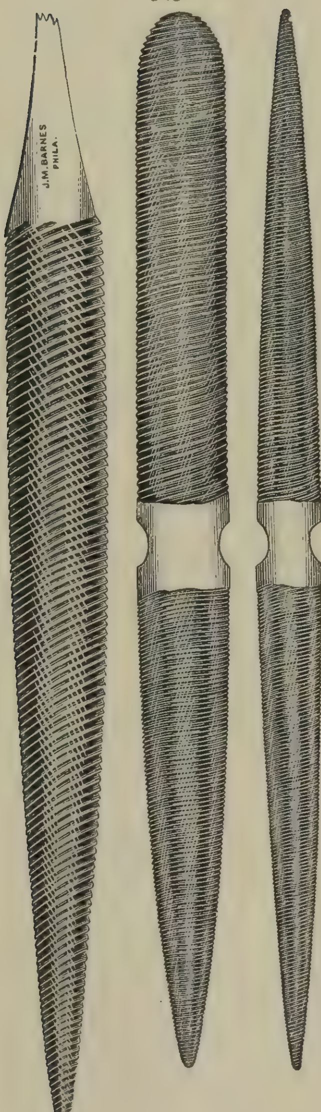


Fig. 544.

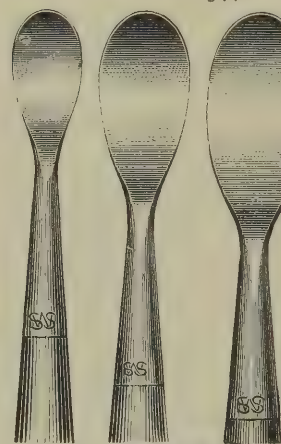


Fig. 545.

Partial Dentures Constructed in a Base of Rubber.—The foregoing description of the method of forming entire dentures in a base of rubber, together with a knowledge of the manner of constructing parts of sets of teeth mounted on metallic plates, will render any extended description of the former process, as it relates to partial pieces, unnecessary. A base-plate of the required thickness and dimensions is accurately adapted to a model of the parts, the narrower portions passing into the spaces between the teeth being stiffened by doubling the plate at these points with an additional strip of the material used. The central portion of the plate may also be temporarily supported, and its form preserved, by filling in the concavity with a layer of stiffened wax. A rim of wax is then attached in the usual manner to those portions of the plate occupying the vacuities on the ridge, when the plate is placed in the mouth and an impression of the points of the opposing teeth secured; it is then removed, reapplied to the model, and the heel of the latter extended posteriorly to form an articulating surface for the remaining portion of the antagonizing model—the latter being formed in the ordinary way. The teeth are then fitted to the vacuities in precisely the same manner as when metallic plates are used, and the wax trimmed to the required fullness. The plate, with the teeth attached, is then placed in the mouth and any necessary corrections made in the arrangement of the teeth; after which it is removed and readjusted.

In constructing partial sets of vulcanite, it is of the first importance, when forming the mold, that the relation of the porcelain teeth to the model of the mouth should be accurately maintained, the reasons for which are fully set forth when treating of the formation of the mold or matrix for full sets. To secure this result with certainty, the following method should be adopted. Having adjusted the plate and teeth upon the model, with the wax trimmed and carved to the required fullness, place the model in the lower section of the flask and fill in with plaster, extending it up to the points of the teeth, binding them to the model, and making the line of separation of the sections of the flask at that point. The ends of the plaster teeth should be cut away sufficiently to allow of a ready separation of the sections.

Plaster is then poured in for the upper section of the mold, and, when hard, the flask is parted and the wax removed from the model and teeth, the latter being retained in the lower instead of the upper section as in full cases.

Metallic Clasps Attached to Rubber Plates.—Although atmospheric pressure or adhesion should be made available in all practicable cases as a means of retaining parts of sets of teeth in the mouth, yet cases occasionally present themselves necessitating the employment of clasps. These may be of rubber, but those formed of gold, or gold alloyed with platinum, are more reliable and better adapted to those cases where the spaces between the teeth are contracted. The following description of the method of constructing them is given by Prof. Wildman:—

"First bend the clasp to fit the tooth accurately; then make the attachment by which it is to be held to the rubber (this may

FIG. 546.

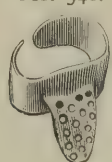


FIG. 547.

be done by soldering a thin plate of gold or platina to the clasp in such a position that it will be inclosed in the rubber); then perforate the plate with numerous small holes, which should be countersunk on both sides (Fig. 546). This plate entering the base, the rubber filling the holes forms pins which rivet the clasp securely to the rubber plate.

"Or the attachment may be made in this manner: On the parts of the clasp that can be covered with rubber drill one, two, or three holes, as the space may admit; insert gold or platina wire, solder with gold solder, then cut off at proper length, and head them (Fig. 547); these act in retaining the clasp in the same manner as the double-headed pins in securing the tooth to the base, and offer the advantage over the perforated plate of being more easily manipulated and less liable to become displaced in packing the mold. The clasp is to be attached to the

model plate, and will remain secured in the mold when it is opened."

A metallic clasp may also be very securely attached to the rubber by drilling a number of holes in that part of the clasp which lies in contact with the rubber, and countersinking them well on the inside of the clasp.

Substitution of Plate for Rubber Teeth.—An ordinary plate tooth, such as is commonly used in connection with a metallic plate-base, can be readily rendered suitable for a rubber base. This is done by soldering a narrow strip of gold plate to the ends of the platinum pins, forming a loop or staple (Fig. 548), and which, embedded in the rubber, renders the attachment very secure. A narrow arm of rubber extending to a single tooth may be materially strengthened by permitting the gold strip, perforated with holes or roughened on its edges, to pass some distance into the rubber, as seen in Fig. 549.

FIG. 548.

FIG. 549.

Instead of forming a loop or staple as mentioned, it will be preferable in many cases to solder to the tooth a somewhat wider strip than that represented, in the same manner as ordinarily practised in backing for gold work, the strip being strengthened by flowing solder at the angle of divergence from the heel of the tooth, and extending thence into the body of the rubber, perforated or roughened on the edges as before recommended. The rubber in this case may be cut away, when finishing, to the angle, leaving nothing but the strip of gold and sub-lining of rubber at the base of the tooth. This method may be resorted to with signal advantage in those cases where, on closure of the jaws, the points of the opposing teeth encroach unduly upon the space to be filled, extending nearly to the gum, requiring the tooth of replacement to be as thinly formed throughout its length as possible.

Repairing.—If a tooth or block has been broken, or any

change is to be made in the position of either, the teeth or fragments thereof are removed, and an irregularly shaped groove or dove-tail formed in the base occupying the space to be supplied; into this space the tooth or teeth are properly arranged and supported with wax; the dove-tail is then filled in with wax, giving some additional fullness to compensate for waste in finishing. All portions of the piece except the lingual face of the plate and teeth are then embedded in plaster in the lower section of the flask. The upper section of the mold is obtained in the usual way. When separated and all traces of wax removed, the gum is packed into the cavity around the tooth or teeth. Grooves are then cut extending out from the mold, the two sections heated and forced together, and the process of vulcanizing conducted in the usual manner, the same time and degrees of heat being required as in the first instance. The renewed heat employed renders the surface of the material previously vulcanized somewhat darker, to remove which it is recommended to moisten the surface with dilute nitric acid for a short time, after which the piece is thoroughly washed, and then placed for a few minutes in an alkaline solution to remove any remaining traces of acid. It is also recommended to immerse the case in alcohol for five or six hours, and then expose it to the rays of the sun for a like period of time.

Dr. A. A. Blount, of Geneva, Switzerland, in the *Ohio State Journal*, suggests the following method of replacing a broken crown without removing the entire section. "Finding it impossible to match the injured block," he says: "I ground the broken tooth down to the gum, as one would for a pivot tooth, and, as I had often done before in mending a continuous-gum piece, selecting a plain rubber tooth the exact size and shape, ground it carefully and accurately to fit, cementing it in place with a plastic cement, which served to hold it firm and prevent the rubber from coming through to the front. The plate being prepared as usual for mending, the piece was vulcanized. After being finished, no one could tell that the block had ever been mended. This method of repairing broken blocks, mounted upon Watt's metal, will be found very practical, as it is somewhat difficult to replace a broken block upon that base."

The whole subject of repairing rubber plates is so fully and clearly described by Dr. George B. Snow, in an article entitled, "Repairing Vulcanite Plates," that his processes are here given in detail. The writer would premise that he has long since abandoned the older methods of "dove-tailing" or "under-cutting" in repairing rubber plates, and would emphasize what is stated by Dr. Snow, "that perfect union can be obtained in such cases if the surfaces of contact are freshly cut, absolutely clean, and properly roughened."

"It is not unusual to see vulcanite plates which have been cracked or broken, and repaired by what may be termed the 'hole and plaster' system. Holes are drilled through the plate along the edges of the crack, and a new thickness of rubber superimposed upon a mass which, possibly, is already too thick for comfort or convenience, the old crack still remaining as a weak point to occasion further breakage. No advantage was taken of any possibility of union between the old and new material, the dentist having been obviously ignorant of the fact that perfect union can be obtained in such cases if the surfaces of contact are freshly cut, absolutely clean, and properly roughened.

"The great point to be remembered in repairing or making any addition to a vulcanite plate is, that the new and old material will unite perfectly, and with such firm adhesion that the plate will be practically as good as new, if the surfaces of the old plate where union with the new material is desired are freshly filed, *absolutely clean*, properly roughened, and of sufficient area. To ensure these results, wax should not be melted upon the surfaces of union in waxing up, and removal of the wax from the mold should be accomplished by means of instruments, and not by hot water, unless, possibly, for the removal of very small particles which cannot otherwise be gotten rid of. Any amount of the old material desired may be cut away, and its place supplied by new; and thus any change wished may be effected. In case of breakage or cracking, the plate should be cut away so that the old defects will be wholly obliterated and new material supplied.

"As a first instance, suppose a partial lower plate, supplying the loss of the bicuspids and molars on both sides of the mouth,

to be broken through the bar which extends from one side of the mouth to the other behind the incisors. The fracture is generally a clean one, resembling that of glass or porcelain, and the two pieces may be brought into apposition with certainty. The dentist holding the parts together in exactly the right position, the assistant covers the lingual side of the plate at the point of fracture with a few drops of hot shellac from a shellac stick. A little cold water follows, and the two parts of the plate are firmly cemented together. A brace is now extended across from the molars on one side to those on the other, by laying a burnt match on the grinding surfaces of the respective teeth, and fastening both ends with a few drops of hot wax. By this means sufficient strength is obtained to allow of the plate being safely handled. A piece of paper or sheet wax is cut to fit and reach across the lingual space at the lower edge of the plate, and fastened therein with wax, a coat of shellac varnish is applied to the paper, the surface lathered with soap-suds, and rinsed, and a model run in the same manner as in filling an impression.

"After this has hardened, the plate is removed from the model, which is then given a coating of liquid silex. This is always preferably done in repairing plates, at the time when the plate is first removed from the model. The rubber bar may now be cut away, on either side of the fracture, by a jeweler's saw, the cut being made diagonally, so as to make what is termed a 'scarf' joint. The surfaces should be further roughened by making a series of shallow parallel cuts across them with the saw, a thick separating file, or a thin wheel-bur. The parts of the plate are then placed upon the model, waxed up, and flasked, the model and buccal surfaces of the teeth being covered with plaster, and the parting made so that the plate will be retained upon the model, while the pieces of the bar can be readily removed. After the flask is opened, the pieces are removed, the usual gateways cut, and the packing, vulcanizing, and finishing done as usual.

"In the case of an entire lower set broken through the center, it will be seen that the same directions will apply, excepting as to the amount of rubber to be cut away. A free cut should be made on the lingual side, extending through under the teeth, to

and including the labial band ; so that the broken surfaces will be entirely obliterated, and at least one-eighth inch in width of new rubber supplied between the cut surfaces. An engine-bur will do much of this work nicely, and a wheel-bur is very convenient for the purpose of scoring the surface. Making the model, flasking, and packing will be done as before.

" If one of the incisor blocks be broken, and needs replacement, a new one can be fitted after the model is obtained, and the remaining steps of the process followed as has been described.

" Upper plates are sometimes cracked in the center, the crack extending from under and between the incisor teeth backward over the palate. This often happens from the amount of rubber just behind the incisors being insufficient. It is not unusual to see it cut away at this point, so that the pins are almost or quite exposed, the plate having its usual thickness at a very short distance behind the teeth. A much larger amount of material will be tolerated here than is usually employed, and often with benefit, not only to the strength of the plate but to the articulation of the wearer. The curve of the surface of the plate should be made to resemble that of the palate before the removal of the teeth, and it will be found that the extra thickness may extend for half an inch behind the teeth without annoyance to the patient.

" A proper curvature to the surface of the plate, just behind the incisors, will do much to prevent the disagreeable whistling in making the *s* sound, and will assist in giving the correct enunciation to *sh*, *zh*, and other linguals.

" If the cracked plate fits a flat mouth, a model can often be drawn from it as it is ; but if the arch is high, and the gums projecting, it is better, after thoroughly cleansing and drying the plate, to finish the cracking by breaking the plate entirely in two. The two halves may now be fastened together by dropping shellac upon the lingual side, and a model secured, from which either half of the plate can be easily removed. The whole palatal portion of the plate can then be removed by a saw cut, leaving only a narrow margin on the lingual surface inside the teeth. The remainder of the surfaces of fracture are cut away as directed in case of the lower plate, the new surfaces rough-

ened, the pieces of the old plate replaced upon the model (which has received its coating of liquid silex), waxed up, flasked, packed, and vulcanized, the teeth being retained upon the model as before described. The plate, when finished, will show the old rim and a margin of the old rubber inside the teeth.

"It is sometimes desirable to change the substance of the plate entirely, as in case of supposed mercurial poisoning by red rubber; or at least to put what red rubber there may be about the plate entirely out of sight, and to reduce its quantity to a minimum. If this is to be done to the plate last under consideration, it should be prepared for flasking as described, excepting that the labial band should be cut away, and everything arranged so that the plate can be separated from the model when flasked. The parts cut away should, of course, be replaced by wax. The case is now set in the flask so as to leave the parting at the upper edges of the gums. The plaster is varnished and oiled, and more plaster built on against the labial sides of the teeth, extending from their cutting edges to the edge of the flask, and again varnished and oiled, so that the appearance will now be precisely similar to a plate flasked so as to be retained upon the model. The ring of the flask is now put in place and filled, and the plaster allowed to harden.

"When the flask is separated, the teeth will be found in its ring section. A few blows of the hammer will dislodge them, with the piece of plaster built against their labial surfaces. This is carefully broken away, in two pieces, if possible, which are preserved, and the teeth and rubber encasing them are left. The rubber is now filed away as much as is practicable, leaving none of the old rubber in sight, and removing enough from the palatal surface to make a new fit to the model. The teeth and plaster are replaced in the flask, and the case is ready for packing and vulcanizing; when finished, none of the old rubber will be seen, and the plate will be practically as good as though the teeth had been removed from the old plate and reset.

"It is evident that the change from red to black rubber just described can be made with a whole plate or a broken one indifferently. If a change of articulation and a new fit to the mouth is also desired, on account of shrinkage of the gums, the plate

should be prepared so as to draw from the model, and a few small pieces of wax put in the palatal side to bear upon the alveolar ridge, and give the right articulation by trial in the mouth, the center of the plate being cut away to facilitate the fitting of the plate to the model. A fresh model of the mouth being secured from an impression, the plate is waxed on to it, the case is flasked with a false piece of plaster built against the labial sides of the teeth, as has been described, and the plate removed and cut away as much as desired, a considerable amount being always taken from its palatal surface.

"This process does all and more than is specified in the Hyatt patent, as it not only gives a new fit, but allows the material of the plate to be substantially changed. Holes and dove-tails, it will be seen, are wholly unnecessary, and the fine serrated edge left by cross-cutting the surfaces of union will be found an excellent guide in scraping the plate to avoid overlaps. The use of shellac as a cement is strongly advised in repairing, as it is rigid and brittle when cold, and the broken parts, if once properly brought together, cannot get out of adjustment without at once attracting attention by the breakage of the cement. Wax does not answer the purpose nearly so well.

"The amount of shrinkage in rubber, from cooling after vulcanization, is not so generally noticed and provided for as it should be. Plates composed of single teeth do not give trouble from this cause, but full plates, on which sections are mounted, are often very vexatious to the dentist, from the changes of shape they undergo from shrinkage.

"The reason of this is, that the ends of the sections abutting form an arch of porcelain, which expands or contracts but slightly from changes of temperature. The rib of vulcanite immediately inside this arch, and in which the pins are embedded, forms a second arch, closely attached by the pins to the first one. The plate is molded to the model, and hardened at a temperature of about 320°, and is afterward placed in the mouth, where the temperature is in the neighborhood of 90°. Under these circumstances the contraction of the rubber which ensues has the effect of lessening the radius of the arch, drawing the heels of the plate together, thus rendering it a little too narrow to fit the

mouth accurately. This has the further effect of elevating the palatal portion of the plate, which, when tried in the mouth, will usually be found to rock slightly,—often so much so as to interfere with its fitting.

"If the plate has been made upon a model taken from the mouth, the difficulty is overcome by warming the back part of its palatal portion, pressing it down slightly, and cooling it while the pressure is continued, the narrowing of the plate being too small in amount to be of itself objectionable.

"This change can be accomplished with more certainty by making a small plaster cast of the palatal portion of the plate, placing upon the part where the change is desired a small piece of folded paper, folded so as to present a thick center, and forcing the plate down upon it after its palatal portion has been heated.

"The shrinkage here alluded to becomes a more serious matter when the plate is re-vulcanized, in the course of repairing it. It is flasked when the change in form by its shrinkage has already once manifested itself, and again heated to 320°; and in cooling a second shrinkage takes place, it becomes still narrower, and its fit, already defective, is made perceptibly worse. It now often becomes a matter of necessity to bring it back to its proper shape before it can be worn with comfort. To provide for this, a small dot should be made with a pointed instrument on each side of the plate, immediately behind the molars, and a pair of dividers set to the distance between these points. After vulcanization, the dividers can be applied to the marks, and they will indicate the amount of shrinkage the plate has experienced. Let the plate now be warmed just behind the incisors, and in the mesial line, by repeated short puffs of a blowpipe flame. This must be done carefully, and the heat not allowed to extend over an area much exceeding half an inch in diameter. When the rubber is sufficiently softened, the plate should be taken by the heels, a pull made upon it sufficiently forcible to expand the arch, and a stream of cold water applied. The dividers will at once show if the change made is sufficient.

"When the plate is now tried in the mouth, it may be that the back edge will not touch the roof, and air will be admitted under

the plate; in which case the back edge should be heated and forced up to its proper position.

"The same remarks apply to full lower plates as well, which often are found to have lost their fit in a measure, after having been revulcanized. The process above detailed will suffice to restore them to their former fit, and render them again comfortable to the wearer."

CHAPTER XIV.

CELLULOID BASE.

The employment of celluloid in prosthetic dentistry, notwithstanding the very general failure which attended its first introduction into practice, came rapidly into general professional favor as a cheap, convenient, and serviceable base for artificial dentures. With the more recent improvements in the manufacture and seasoning of blanks, more perfectly adapted appliances for molding, and a more extended acquaintance with the peculiar and distinctive characteristics of this material, it has, in the practice of many, superseded, in a great measure, other plastic vegetable substances for the purpose indicated.

That celluloid possesses many important qualities which commend its employment as a base in preference to rubber can hardly be questioned. It is more in harmony with the soft tissues of the mouth, more cohesive in texture, approximates more nearly the natural gum color, contains far less vermilion pigment in its composition, and is less objectionable by reason of the comparative cleanliness accompanying its manipulation.

The chief objection urged against celluloid as a base is its low power of transmitting caloric, but it is believed to be less objectionable in this respect than rubber. Both are poor conductors, and the soft tissues of the mouth in contact with either suffer, in some degree, as a consequence of this property.

Celluloid, as at present produced, and when properly manipulated, does not, in any appreciable degree, undergo change of form after molding by warping either in or out of the mouth, as was formerly the case, nor does it absorb the oral secretions. It loses somewhat the freshness and clearness of its original pink color, however, after having been in use for some time, in many cases in a very marked degree.

Though not bearing so perfect a resemblance to the com-

plexion of the healthy gum tissue as the porcelain imitations, yet the near approximation of celluloid to the desired color makes the use of single plain teeth admissible for permanent dentures, and this is unquestionably its crowning merit, and makes it the most desirable of all the so-called "cheap bases." The indiscriminate and almost universal employment of block or sectional gum teeth in connection with rubber has done more to degrade the prosthetic department of dental practice than all other causes combined. The optional arrangement of each individual tooth to meet the requirements of special cases in respect to expression, articulation, and antagonism is one of the absolute and indispensable requirements of a perfect artificial denture. A more general recognition of this important fact must, sooner or later, lead to the entire abandonment of rubber in connection with "ready-made" sectional gum teeth. "Taking into view all its qualities," says a well-known writer, "and leaving out the question of freedom from monopolies, the conclusion is that celluloid has the potentialities which should dethrone rubber, and establish itself as the best of the cheap bases."

Composition and Manufacture.—The following is the substance of Prof. Charles J. Essig's account of the composition and manufacture of celluloid:—

Celluloid is derived from cellulose, a woody fiber, constituting the framework or foundation of plants.

Linen, cotton-wool, hemp, etc., are examples of cellulose. For the manufacture of celluloid, the cellulose is first converted into paper; hemp is the form of cellulose employed for this purpose, because it has been found to make the strongest paper, and the stronger the paper the better the celluloid.

The hemp is first converted into paper in the usual way by paper machines. By this process the form of the material undergoes a physical change only, while chemically it remains the same, viz., nearly pure cellulose, and has a formula of $C_6H_{10}O_5$. The cellulose, now in the form of hemp-paper, is converted into pyroxylin by a process technically known as "conversion," this change being effected by immersing the hemp-paper in a strong mixture of nitric and sulphuric acids for a sufficient

length of time, when it is removed from the acids and washed thoroughly.

It is now still in the form of paper, but it will be found to have increased in weight about seventy per cent., and to have become highly explosive, taking fire at about 300° F.

Pyroxylin, then, is the chief ingredient in celluloid, and is reduced to a pulp in a machine similar to that used in paper-making; a thorough mixture is then made of—

Pyroxylin,	100 parts.
Camphor,	40 "
Oxid of zinc,	2 "
Vermilion,	0.6 "

Some alcohol is used to soften the camphor. The mass is now put under a hydraulic pressure of two thousand pounds to the square inch. The cylinders in which it is pressed have a small orifice in the side near the bottom, and when pressure is made the celluloid is forced out through this orifice.

The immense pressure is to condense or solidify the celluloid, and as it is forced out it is cut off in pieces of the proper size, and molded by pressure and heat to the forms in which we receive it. At this point the blanks are still soft, and require to be seasoned; this requires about two months, during which time they are kept in a room at a temperature of 160° F.

Processes Preliminary to Molding.—While many of the processes entering into the construction of artificial dentures, with celluloid as a base, are essentially the same as those required when rubber is used, yet there are, in many important respects, modifications of practice made necessary by the peculiar nature and behavior of the material employed.

When the distinctive characteristics of celluloid are well understood, and the operator is familiar with the approved methods of working it, no unusual difficulties attend its successful manipulation. To attain uniformity and satisfactory results, however, it is absolutely necessary that there should be a faithful compliance with every manipulative detail, however seemingly unimportant, which experience in the use of this substance has demonstrated to be essential.

Plaster Model.—The inferior plasticity of celluloid, compared with vulcanizable rubber, when exposed to the action of heat, and the consequent greater pressure necessary to mold it into any given form, makes it necessary to give to the plaster model the greatest practicable hardness and strength. To secure these important qualities it is recommended to use the best quality of coarse builder's plaster, which, though it does not set so quickly as the finer and whiter varieties, becomes much harder and more resistant to pressure when thoroughly dried. Increased hardness will be secured by adding to the plaster mixture a small quantity of clean white river or lake sand or marble dust.

A smoother face will be given to the model by first coating the surface of the impression with a moderately thin mixture of fine plaster, and as this begins to set, fill in with the coarser variety for the body of the model.

The plaster for the model should be mixed as thick as can be well poured, taking care, as it is slowly introduced, to expel any confined air by tapping or shaking the impression-tray as the plaster flows in.

In cases where there is any considerable anterior projection of the alveolar ridge in front, above or below, the corresponding portion of the plaster model is liable to be crushed under the pressure necessary to mold celluloid. To prevent such accident, it has been recommended, in addition to the expedient to be mentioned hereafter, to place in the front part of the impression a curved piece of brass plate punched full of holes, one-half or three-fourths of an inch wide, which, when the impression is filled, will be embedded in the central portion of the plaster ridge, and extend some distance into the body of the model.

Metal Casts.—In extreme cases, where the ridge is very thin and the projection spoken of excessive, it is safer and better practice to substitute metal for plaster in forming the model. In this case the latter may be obtained by pouring block-tin or Babbitt metal directly into the plaster impression, which should first be thoroughly dried, and the cavity for the air-chamber formed before pouring.

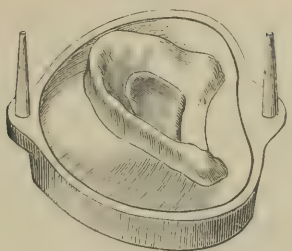
A solid metal cast, however, should never be employed when there is any considerable undercutting, as is often the case on

either side of the median line in front, forming the canine fossa, and posteriorly underneath the maxillary tuberosities, since, in such cases, it will be impossible to detach the metal cast from the case when molded. The separation can be readily effected by substituting a metal shell for the solid cast. The shell is formed in the following manner: Secure a perfect mold of the plaster model in sand, and fill into this with fused block tin of the purest kind, pouring it as hot as can be poured without producing bubbling of the metal. As the metal cools first at the surface, a shell will form externally in a few seconds, when the box containing the mold should be inverted and the central fluid mass poured out quickly at the back part of the mold in order to secure the thinnest portion of the shell in front, where it should not be thicker than ordinary card paper. A little practice, with a few failures at first, will enable the operator to secure the desired thickness of the shell with tolerable exactness. When obtained, the shell is filled in with hard-setting plaster to form the metal-faced model to be used in molding the celluloid. When the case is finished and the plaster removed from the shell, the overlapping borders of the latter may be readily drawn in toward the center with pliers, and the shell disengaged from the undercut spaces. To facilitate its removal, the shell, before filling in with plaster, may be divided vertically at intervals with a fine saw, extending the cuts from the margins to near the summit of the ridge.

Waxing or Modeling.—After having arranged the teeth for any given case, place them with the trial plate on the model, and build out with wax, paraffin and wax, or modeling compound. In carving or modeling these materials, much time and labor may be saved in final finishing of the piece, and a more compact surface given to the celluloid, by securing in the first place the exact form and fullness required in the completed set. When this is done with instruments especially adapted to the purpose, the general forms of which are represented in Fig. 550, additional smoothness of the surface may be obtained with a blowpipe flame applied in such a way as to produce simple surface fusion of the wax or other material. The palatal and exterior surfaces may then be covered with No. 60 tin foil, carefully burnished into

FIG. 550.

FIG. 551.



close contact. A closer imitation of the granular appearance of the natural gum exteriorly may be obtained by pitting or "stippling" the surface with a small pointed instrument, care being taken not to perforate, but simply indent, the foil; or a flat-faced serrated plugger may be used for the same purpose.

Investing.—The piece prepared as above is then placed in a flask especially designed for celluloid (see Fig. 551), invested in plaster, and the mold or matrix formed in the same manner as practised when rubber is used. In case the ridge overhangs, or is undercut, the model, before being encased in the lower section of the flask, should be cut across diagonally, with the slope toward the heel of the model, thus depressing the latter posteriorly, as exhibited in Fig. 551. By this means the projecting portion of the ridge will be brought more directly in a line with the pressure in closing the flask.

It is quite as important that the encasing plaster forming the matrix

should be as hard and resistant to pressure as that entering into the composition of the plaster model. If this condition is not secured, there will be great danger, not only of fracture of the model for the want of adequate lateral support, but of displacement of the teeth by being forced into the plaster. So important is the right condition and manipulation of plaster in the use of celluloid, that the author feels warranted in adding, to what has already been said in this connection, the following judicious comments contained in a pamphlet issued by the manufacturers of celluloid:—

"Plaster should always be mixed *as thick as possible*, and, if convenient, allowed to set overnight, with the flask open, and dried in a warm place, as it is thereby rendered much harder. Simple as the operation is, comparatively few understand how to mix plaster so as to get the greatest strength and resistance to pressure. The proper way to mix plaster for both models and filling flask is as follows: First, stir the plaster as thick as can be well poured, taking care that there is no excess of water; pour some of this into the flask or impression to be filled, and shake down well. Then, into what remains in the bowl, stir more plaster until you have a mass so thick that it can be piled up. With this the flask is filled up and thoroughly shaken down. It is surprising how much plaster can be stirred in after the first is poured out, and also how thick a mass, such as described, will settle down in the flask without bubbles. The thinner plaster first poured in will run and be driven, by the thicker afterward added, into all the crevices, and most of it will escape from the flask, leaving a body of solid, resisting plaster that cannot be obtained by the ordinary method of mixing."

In flasking the case, *the line of separation between the upper and lower sections should be along the borders of the plate.* This is particularly necessary when the gum is "stippled." When the piece is incased, and the plaster has sufficiently hardened, the two sections of the flask should be carefully separated, and this can be done with greater safety to the model and other portions of the matrix, and with less liability of loosening and detaching the teeth from the plaster, by first applying just sufficient heat to the flask to soften the wax and trial plate,

being careful not to melt the wax by too great or long-continued heat.

When the flask is separated, all portions of wax or other material should be carefully and thoroughly removed from the mold, and if any remain, not accessible to instruments, the section or sections of the flask containing remains of wax should be placed in a clean vessel under clean water and well boiled until all is expelled. The thin, frail edges encircling the matrix in both sections of the flask should then be cut away somewhat, and well rounded to prevent fracture and consequent mixing of particles of plaster with the celluloid in molding. When this is done, put the flask together and see if there is ample room for the "nose" of the model to pass the edge of the matrix.

To permit the escape of surplus material in molding, either of the following plans may be adopted: 1. Cut two concentric grooves in the plaster of the upper or lower section completely encircling the matrix, the inner one not less than one-fourth or one-sixth of an inch from the margin of the mold, and the other at the border of the flask, the inner side of the latter forming a part of the outer groove. 2. Bevel the plaster around the mold, commencing about one-fourth of an inch from the margins of the latter and extending it to the sides of the flask. 3. Cut cone-shaped cross or radiating grooves from the inner circular gutter to the margins of the flask,—shallow where they connect with the circular groove, and deepening and widening toward the edges of the flask.

In no case should cross grooves be made communicating with the matrix, as these afford too ready an exit for surplus material, and prevent that "back pressure" so essential to a complete and compact filling of the mold. The grooves should be deep and ample enough to receive all surplus, otherwise it would be difficult, if not impossible, to close the flask perfectly. In the use of gum teeth, holes may be drilled in the matrix inside the teeth, opposite each joint, not over an eighth of an inch in diameter, and as deep as it may be deemed necessary. These act as waste gates, and relieve the blocks from pressure.

Selection and Preparation of the Celluloid Plate or Blank. —The mold having been prepared in the manner described, a

suitable blank should be selected, and, as it is important that this should be, as nearly as possible, the size and general form of the mold, a good assortment of plates, for both entire and partial pieces, should be at command from which to select for any given case. Special attention is directed to this important requirement. Celluloid does not, like rubber, flow together and intimately intermix when exposed to heat and pressure. If, therefore, the blank is, in any considerable degree, wider than the model, or its central or palatal portion fuller and deeper than that of the model, the material, when under pressure, will lap or fold upon itself along the lateral walls of the arch, and, failing to unite, will form grooves or fissures. On the other hand, if it is not wide or deep enough, the material is liable to be stretched and torn. The blank should be just large enough to fill all parts of the mold perfectly, with some slight excess, and the central portion should always be somewhat thicker than the corresponding part of the trial or pattern plate.

As celluloid cannot be depended on to flow from one part of the mold to another, it is important that there should not only be an excess of material, but that this excess should be, as nearly as practicable, distributed throughout all portions of the matrix. A neglect of this precaution will result either in an imperfect filling of the mold in some places, and consequent defect of the plate, or a porous condition of the celluloid will be found wherever the material, though apparently filling the mold, has not been impacted with sufficient force.

The selected blank should be conformed as nearly as possible to the shape of the mold by heating it in boiling water and pressing it with the fingers into the section of the matrix containing the teeth; after which the necessary fullness of the several parts of the blank may be obtained by dressing away redundant portions with files, a small bracket saw, or the knife, first softening the plate in boiling water before using the latter.

Greater exactness in the required amount of celluloid necessary in any given case may be obtained by measurement, the simplest method being by the use of the Starr instrument, illustrated in the chapter on Vulcanite. It must be remembered, however, that this device only determines the aggregate

amount of material necessary, and that, while it may be a safe guide in the use of rubber, which flows freely, it may lead to failure when celluloid is employed, unless care is taken that all parts of the blank correspond with the capacity of the mold.

A more reliable though somewhat tedious method of securing exactness in the quantity and distribution of material necessary, and which acquires special value in cases where there is unusual danger of fracture of the model or teeth, and especially of the latter when gum teeth are used and these are ground very thin, is the following, given by a correspondent of the *Dental Cosmos:* "After preparing the case ready to flask, remove the teeth from the pattern, stop the pin-holes, then remove the pattern and carefully flask it. When the mold is ready, remove all the wax or material of the pattern; place the celluloid 'blank;' apply heat, and cast the same as if for final case. Remove the flask from the heater; place it in the clamp and cool rapidly. When it is entirely cool, remove it from the flask, and trim as carefully as for final case until the blank is almost the same as the pattern in thickness (it always comes out thicker). Now you have a blank with but little excess;—only what the vacuum and pins displace, or slightly more, and exactly the shape of the pattern, minus the teeth. Set up the case again, being careful to make the pattern the same size; flask, and when ready remove the pattern; if doubtful as to amount of excess, pare the edges of the mold slightly, which will be all that is needed. Replace the blank; apply heat, when but moderate pressure will be found necessary to bring the flask entirely together. If dry heat is preferred, dip the edges of the blank to come in contact with the pins in spirit of camphor for a few minutes before casting."

Before the blank is placed in the flask preparatory to molding, some provision should be made against adhesion of the plaster to the plate. This may be done by oiling the surface of the model, or by coating it and other portions of the matrix with either collodion or liquid silex, or by rubbing the surfaces well with French chalk or powdered soapstone; or a layer of tin foil may be interposed between the model and blank. The following

novel method of coating the surface of the model with tin is recommended by Charles P. Alker, of Bordeaux, France: "Reduce ordinary collodion with about three times its bulk of ether, and add powdered tin until the solution is well impregnated with the metal. The tin is the same that is sometimes used for coating plaster images. When properly mixed and applied with a brush, an even covering of tin is formed upon the model, so dense as to closely resemble tin foil, and so firm as to not be detached by boiling water or heat. The plate is readily cleansed with a coarse brush, and presents the appearance of having been made in a metallic mold."

More perfect results, however, it is believed, can be obtained in the use of a metal-faced model in connection with the use of tin foil, as before described. A piece thus encased in metal will require no more final finishing than is necessary to remove surplus material and dress and polish edges.

The case, thus described, is now ready for molding.

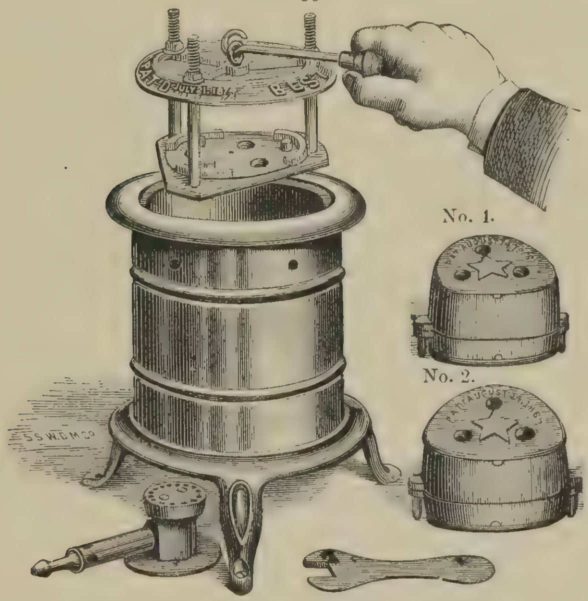
Molding.—The various machines or heaters now generally employed in molding celluloid into dental plates contemplate the use of either glycerin or oil, steam or dry heat, for the purpose of producing the requisite plasticity of the material subjected to pressure. There is considerable diversity in the form and construction of heaters designed to utilize these several mediums for the conduction of heat, as well as differences in the modes of applying pressure, and while each has, doubtless, some special points of merit not possessed by others, satisfactory results may, with careful and intelligent manipulation, be attained by the use of any one of the many recommended. The limits of this work will only permit the introduction of such as are believed to be in most general use.

Hot Moist Air (so-called "**Dry-Heat**") **Machines.**—In the use of these heaters, the water with which the plaster is impregnated is relied upon to produce the steam necessary to carry off all excess of camphor from the celluloid in the process of molding. An essential point by this method is to have the plaster in the flask thoroughly wet, and this may be better attained by setting the flask in a vessel of water before placing it

in the heater. To provide against insufficiency of moisture in the plaster, a small quantity of water may be introduced into the tank before applying heat.

Fig. 552 represents a modeling or packing machine of the class here spoken of, and is designated as the "Best." The inside chamber is of cast-iron, surrounded by a sheet-iron casing. The lid, of cast-iron, forming a part of the clamp, is pierced for the passage of three wrought-iron screw-bolts,—the nuts being on the upper side and easy of access. When these

FIG. 552.



nuts are turned for the purpose of closing the clamp, the bottom portion of the clamp is drawn up by each revolution away from the flame, thus avoiding the danger of overheating the plate, and securing a uniform heat. The bottom of the cast-iron chamber and the lid are pierced with holes, to allow a circulation through the chamber, for the purpose of carrying off the camphor which is disengaged in the process.

With the celluloid blank adjusted to its proper position in the flask, the latter is placed in the clamp and the top screwed down

until it slightly presses the clamp. It is then placed in the oven or tank and heat applied.

If gas is used, the form of burner shown underneath the heater in Fig. 552, which gives a pure blue flame without smoke, may be used. If gas cannot be commanded, however, any of the alcohol or kerosene lamps commonly employed in vulcanizing may be substituted; or the "Hot Blast Oil Stove," especially adapted to the "Best" machine, and exhibited in connection with the latter in Fig. 553, and its construction in detail shown in sectional diagram, Fig. 554, will be found convenient and efficient.

Having applied the heat, it is of the first importance that unremitting attention should be given to the process of molding until it is completed. If pressure is applied before the celluloid is rendered somewhat plastic, or too great force is exerted during the earlier stages of the process, and without sufficient intervals of rest, there is danger of crushing or fracturing the model and of impairing the articulation by displacement of the teeth. On the other hand, the nature of celluloid is such that if it is exposed to a temperature of 270°, without being under pressure, the camphor evaporates, and the material, besides being rendered hard and intractable, is puffed up, exactly as a loaf of bread is raised by yeast, and filled with air cells, and thus rendered porous.

Celluloid begins to soften at about 225°, and will then yield slightly to pressure, but this should be applied very gently at first, with no more force than can be readily exerted with the thumb and finger. As the heat increases, and the celluloid becomes more and more plastic and yielding, the pressure should be correspondingly increased, but always interruptedly, giving the material time, between each turn of the screw or nuts, to escape from under the pressure. No considerable amount of pressure will be required in any case until near the close of the operation, when the mold is completely impacted, and the excess is being forced into the grooves or gateways as the flask comes together.

At this point considerable force will be necessary to close the flask perfectly, and somewhat longer intervals of time should occur between each turn of the screw or nuts.

During the progress of the molding, the flask should be withdrawn occasionally for inspection. If, in the case of central pressure, the flask is found to be closing unevenly, it should be loosened in the clamp and readjusted in such manner as to correct the faulty approximation. No difficulty will be experienced in this respect in the use of clamps provided with screw-bolts, as pressure may be applied at any point, and the flask be made to close uniformly without the necessity of shifting the latter.

FIG. 553.

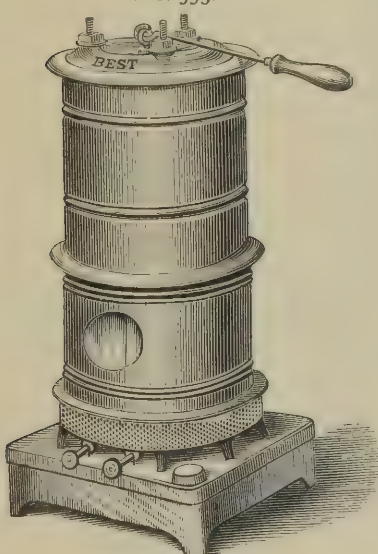
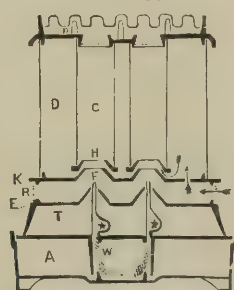


FIG. 554.



A. Reservoir, made of galvanized iron. B. Top of reservoir. C. Chimneys. D. Drum. E. Hanging partition, which keeps the radiated heat from reservoir. F. Principal air deflectors. H. Supplementary air deflectors. T. Tank surrounding wick tube. R. Perforated ring through which all the air that supplies the stove passes. W. Wick chamber. X. Wick tubes.

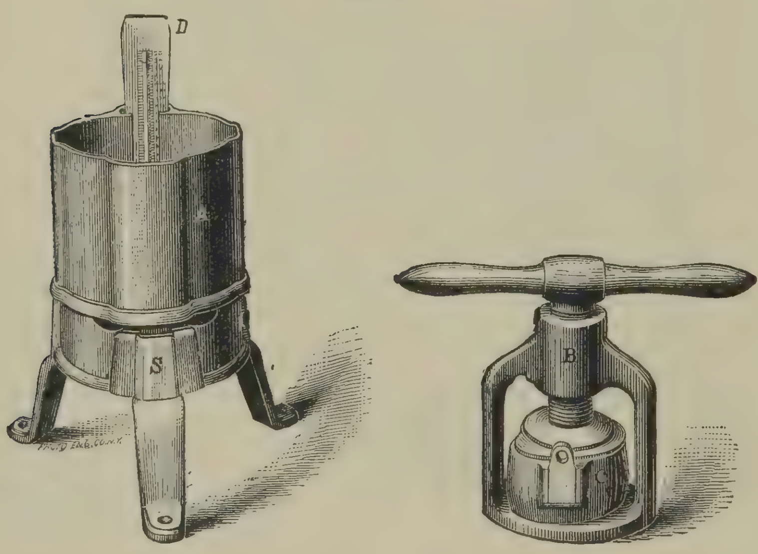
The moment the flask is completely closed, the heat should be turned off, and the piece allowed to cool gradually. In no instance should the flask be removed from the clamp (unless securely locked, as is practicable with the "standard" flask)* until it is *stone cold.* In cases where the material is of extra thickness, or where the shape of the blank is totally altered, longer seasoning is advisable, and the flask should be placed near a stove or over a register (keeping it closed by a clamp,

* Manufactured by the Celluloid Company, and represented in Fig. 555.

or by an instrument or piece of iron put through the holes in the standard) for half a day or more, at a temperature not over 140°. If these directions are observed, no trouble from warping plates will be experienced.

Molding in Glycerin.—Glycerin, as a medium of imparting heat in the process of molding celluloid, has almost entirely superseded the use of oil, paraffin, and other allied substances originally employed. It is a favorite method with many practitioners, and is recommended by the manufacturers of celluloid

FIG. 555.

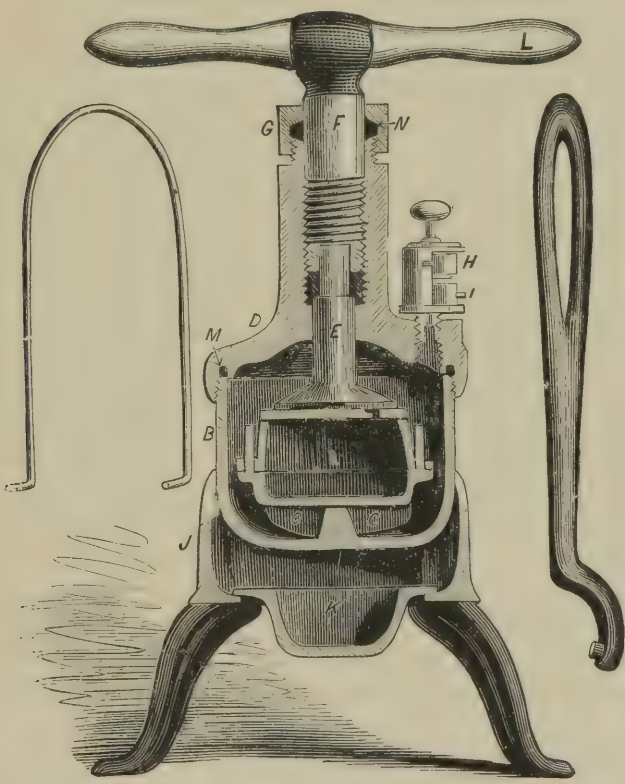


as superior to any other. The long and familiar acquaintance of these parties with the composition, nature, behavior, and treatment of the material they produce entitles their opinion and preferences to more than ordinary consideration.

The improved glycerin apparatus manufactured by them is exhibited in Fig. 555, consisting of a tank, A, for containing the glycerin; a stand, S, with detachable legs, L, which slip into slots, as shown at S; an alcohol cup, shown at K in sectional diagram of steam machine, Fig. 556; a screw clamp, B; a flask, C; and a thermometer, D, to indicate the heat.

Either alcohol or gas may be used with this machine. When kerosene is employed, the manufacturers recommend the use of the "leader" oil stove. When this stove is used, the long legs of the steam machine must be substituted for the shorter ones represented in Fig. 555.

FIG. 556.



M and N, in the sectional drawing, represent packing, to make the boiler steam-tight.

Having placed the blank in the flask, put the latter into the screw clamp and turn down the screw until it touches the flask lightly; set the whole into the tank and pour enough glycerin into the latter to come up to about the top of the flask. Apply heat, and proceed with the molding in the same manner as

described in connection with the "moist air" method. The heat should not be permitted to rise much above 280°. If the flask is not closed when that temperature is reached, reduce the flame, and do not hasten the closing. A little practice will enable the operator to graduate the pressure exactly, without reference to the thermometer.

Molding in Steam.—A sectional diagram of the best adapted apparatus where steam is used in molding is shown in Fig. 556. It consists of the following parts: The base, or standard, J (now made with detachable legs, as in cut of glycerin machine); the boiler, B; the cover, D, to which is attached the safety valve, H; the plunger, E, and alcohol cup, K; the screw, F, for closing the flask, operated by the handle, L; the gland or packing ring, G, the object of which is simply to prevent the steam from leaking around the screw; and the wrench or spanner.

The stand is the same as that for the glycerin machine shown in Fig. 555, and is furnished with short legs, as shown in that cut (for alcohol or gas), or long legs as above, as desired. To use the old steam machine with the "Leader" stove, it is necessary to order only the improved stand with long legs. The company always send the short legs unless otherwise ordered. The following are the directions given:—

"In using the steam machine, care should be taken to keep it in good order. The screw should be well oiled with only the best sperm oil, which will not gum, and kept so that it can be easily turned with the thumb and finger. If the machine, when received from the depot, works hard, the screw should be run out, the gland unscrewed, and the rubber packing loosened up, so that it will not bind the screw. Do not turn it down tight again until you heat it up, when, if it begins to leak, it can easily be tightened. Bear in mind that *turning this gland merely prevents the escape of steam, and does not affect the pressure on the flask.*

"The safety-valve should be kept free from gum, and if either it or the screw is clogged, it should be well cleansed with kerosene. This valve, in the machine now sold, is so constructed that it blows off at about 275°, a temperature that celluloid will bear very well; and as the heat, *so long as water remains in the*

boiler, cannot, if the safety-valve is kept in order, be raised above that point, it is impossible to *burn* a plate in this machine While this is true, it is also true that *too long* an exposure to even 275° in steam tends to injure the quality of the celluloid, and for this reason the heat should be continued no longer than necessary, but should be reduced at once by blowing off steam as soon as the molding is completed. The first machines were constructed with the safety-valve much heavier, and all in one piece, and were adjusted to a temperature of nearly 300°, which was higher than necessary or advisable. It is recommended, therefore, that those having that style of valve should cut off about one-fourth in weight from the lead weight, which can easily be done by removing a little wire which passes through the stem and weight. A modern valve will be furnished when ordered. When molding, fill the boiler partly full of water. The amount is not material, but there should always be enough to cover the ribs at the bottom. Have the screw well turned back, until the plunger, when placed in position, will rest against the top of the boiler, otherwise the flask may be pressed upon while screwing down the cover and the cast injured. Turn down the cover snugly; see that the gland is turned back, and the screw works freely. Many failures have occurred by neglecting this simple matter. If it works hard, it is impossible to tell how much or how little pressure is being exerted; there may be too much, and blocks or cast be broken; or too little, and the plate made porous. In all methods of working celluloid, the *sense of feeling* is the best guide as to when and how hard to turn; but in order to have this, there must be perfect freedom of motion of the parts. The *time* elapsing before turning is not reliable, as it varies with the heat employed, the temperature at starting, the amount of water in the boiler, the drafts of air to which the flame may be subjected, etc.

"After placing the flasks in position, turn down the screw *very gently*, with thumb and finger, until you feel it touch the flask. Fill the cup with alcohol and light it, or light the gas. The safety-valve is made in two parts. The upper portion may be suspended by the pins in the lead weight; the valve will now blow off steam (if in proper order) at a temperature of 225°.

Until this occurs, no particular attention is necessary, but from that time the exclusive attention of the operator should be given to the molding. Many failures occur from the want of this, for the plate may be easily injured from too much heat without proper pressure. But fifteen or twenty minutes, at the most, will be required from this point, with proper heat, and nothing else should be attended to.

"At the point when the steam escapes from the valve with the upper portion suspended, the plate will soften, and the screw will be felt to yield to light pressure with thumb and finger. The upper weight should now be dropped down. Turn the screw *very carefully*, stopping when you feel the resistance increase; as soon as it yields again, turn it more, going slowly and carefully at first, but increasing the pressure somewhat as the steam gets up, which you will know by occasionally raising the valve. It is just here that judgment is required to avoid, on the one hand, too much pressure before the material is sufficiently softened, which would result in fracture of the cast or blocks, disarranging the articulation, or a 'flaky' plate; and, on the other, too little pressure after the heat is up, which would result in injuring the quality of the material. The pressure should be followed up as the heat rises and the screw yields, the object being to get the whole of the plate under pressure, in every part of the mold, by the time the steam blows off quite sharply and steadily on raising the safety-valve. After this the pressure should be increased, but time should always be given between the turns for the slowly flowing celluloid to escape from under the pressure. Toward the close of the process, the pressure should be considerable; in fact, about all that can be applied with the machine, and should be continued as long as the screw can be turned. If the operation has been properly timed, the steam will blow off at the safety-valve at about the time the molding is completed and the alcohol in the cup is consumed. If it should blow off before that, no harm would be done, as the heat cannot become too great if the safety-valve is kept in proper condition. These remarks apply to the use of alcohol in the cup furnished with the machine. If any other heat is used, the flame should be sufficient to complete the process within thirty to forty

minutes. If more than this time is consumed in the molding, the quality of the plate is injured.

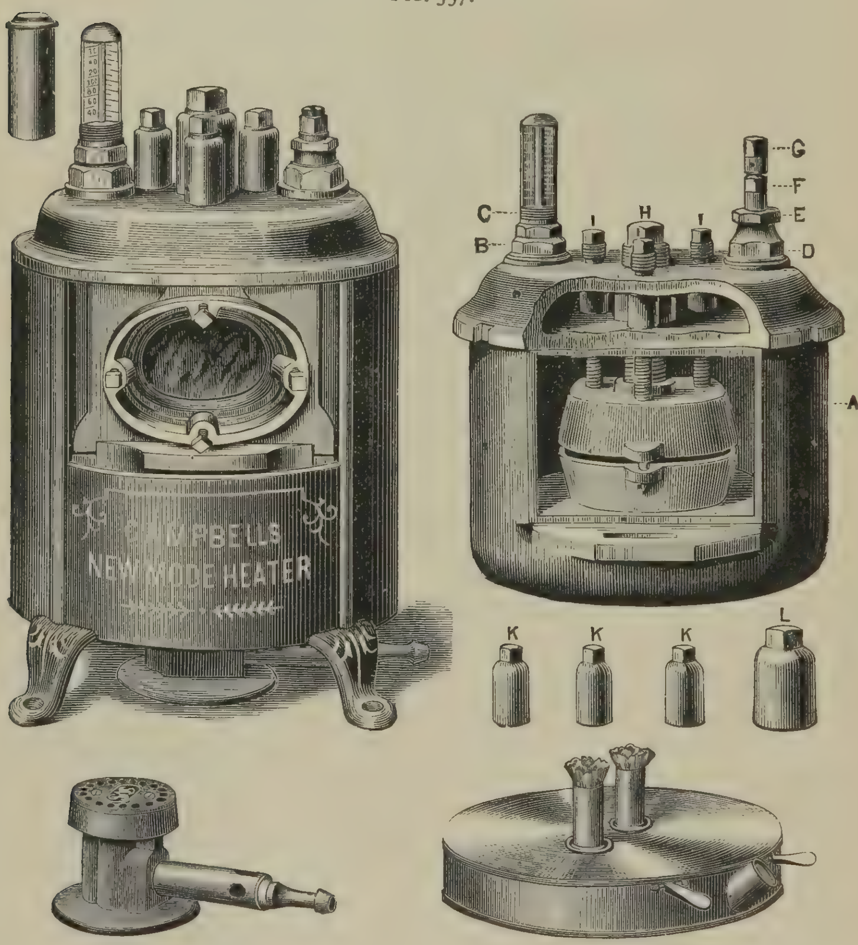
"Do not allow the water to be all converted into steam, as the steam would then become superheated, and a dangerous condition ensue or the plate be ruined, while the safety-valve would not indicate it. Always have plenty of water in the boiler, and if steam should cease to issue on raising the valve, the heat should be at once withdrawn."

It has been demonstrated by experimental tests, and is now very generally conceded, that the best results are obtained in the use of celluloid by subjecting it to *dry* heat in the process of molding, the material, when exposed to a high temperature under such a condition, retaining most perfectly its form, color, and consistency. Hence the celluloid presses of more recent introduction, while they are also equally well adapted to vulcanizing by the same means, are provided with a distinct chamber in which hot air, of a higher temperature than can be safely employed with glycerin or steam, is utilized to secure the greatest practicable plasticity of the celluloid. Approved appliances of this kind are those devised by Drs. Seabury, Evans, and Campbell. The former two have already been described in the previous chapter.

The New Mode Heater.—Dr. Campbell's apparatus, familiarly known as the "New Mode Heater," exhibited in Fig. 557, is constructed as follows: The apparatus, designed alike for vulcanizing and molding celluloid, used more generally, perhaps, for the latter purpose, consists of a cylindrical cast vessel, having two chambers, one within the other, the inner one being supported by piers or columns connecting its sides, top, and bottom with those of the outer chamber, the whole being made in one casting. The outer compartment is the steam chamber or boiler, and encloses the hot-air or packing chamber on all sides, except the front, where the walls of the two chambers converge and become one, for the purpose of permitting access to the packing chamber. A door made of the same metal as the boiler, and fitted with lead packing, to make it steam tight, is held in place by a bridge secured with screws. The door is also provided with a plate-glass light (shown in cut), through which the operator can watch

the progress of the molding in the oven. The only communication between the chambers is by means of a valve having its seat in the top of the packing chamber, and controlled by a hollow stem which passes through the top of the machine.

FIG. 557.



B is a mercury bath; C, thermometer; D, screw plug; E, lam-nut; F, stem of steam valve; G, screw cap; H, large screw for closing flask; I, I, I, smaller screws for same purpose; K, K, K, L, nickel-plated caps for screws; O, O, steam chamber.

The packing chamber is heated by steam generated in the outer compartment, which is kept filled with water on a level with the top of the oven. The water is introduced through an opening in the top and side of the boiler, into which the thermometer is screwed, and which may be removed for the purpose. Steam may be introduced from the boiler into the packing chamber by partly unscrewing the lam-nut, E, or wholly excluded by tightening the same. With this arrangement, an absolutely dry packing oven is possible in molding. The following directions in the use of this heater are given by the inventor:—

"To secure the best practical results, celluloid should be molded or pressed into the form desired at the highest possible temperature which will not burn it. To prove this, it is only necessary to mold a plate on a metal cast at the lowest temperature at which it can be done, which is less than 212°, and another on the same cast at the highest temperature possible, say 310° or 320°, and lay the two aside for a few days, when it will be found that the one molded at the lower temperature will not fit the cast, while that molded at the higher temperature will fit as well as when first made. The reason is that the low temperature fails to overcome the tendency of the plate to return to its original form, while the high temperature renders it so thoroughly plastic that this tendency is entirely eradicated. This is proportionally the case with pieces made at intermediate temperatures; the higher the temperature to which the plate is subjected in molding, the more exactly will it hold its new form and the less will be its tendency to warp.

"Celluloid may be readily and safely manipulated in the New Mode Heater at 320°, a temperature many degrees higher than is deemed safe in other machines, and which accomplishes perfectly the result above noted, and produces a plate which is believed to be absolutely unchangeable in color, form and texture. When this very high temperature is employed, the celluloid should be in the machine only long enough to permit the closing of the flask, for the reason that heat vaporizes the camphor—the solvent of the material. If too much of this is driven off before the flask is closed, it will be almost impossible to mold the blank to the desired form. The sooner the flask is closed

after being placed in the oven, the more readily will it be done, and the better will be the result.

"The molded surface of a piece of celluloid is much more durable than its interior, and will retain the color better. It is obvious, therefore, that this surface is essential to the integrity of the plate, and should be preserved intact. To insure this, the case should be so prepared that the plate, when taken from the flask, will require little or no labor to make it ready for use. It is possible that some surplus material at the edges may have to be trimmed off and the edges smoothed, but the case is not properly prepared if more than this is necessary. The care and trouble involved in proper preparation will really save time, will absolutely avoid interference with the fit by the too free use of files, sand paper, pumice, etc., and will insure a durable plate with a permanent imitation of gum color. Moreover, the artistic taste of the operator may be exercised before the plate is molded more readily than afterward.

"Paraffin and wax compound is used for the base-plate, according to directions before given, and the teeth arranged, the wax carved into the shape desired by means of carving tools, and made smooth. The piece is then invested in plaster, the usual grooves cut, the wax, teeth and tin foil being removed with the upper half of the flask in parting. The wax is then removed by means of boiling water, as before described, the tin foil, No. 60, used for covering the paraffin and wax plate, remaining upon the plaster; the investment is now ready to be dried out preparatory to receiving the celluloid.

"**Drying the Cast and Investment.**—To dry a plaster cast and investment, and keep them free from cracks and checks, is very difficult by the ordinary means, but with the New Mode Heater it can be done so perfectly as to permit their use in casting pure gold or gold alloys.

"There are two ways of drying the investment in the New Mode Heater; first, by raising the temperature to 320°, keeping the hot box dry; second, by admitting steam to the hot box. The former method can be used when the investment is placed in the chamber before getting up steam. If steam is up, however, either method may be employed. In using the dry-heat method,

open very slightly the screw cap of the piston or valve-stem, to permit the escape of the steam generated from the water in the plaster, being careful that the steam-valve is firmly seated, as otherwise all the steam made in the boiler will escape. In using steam for drying, admit the live steam into the chamber with the investment, by raising the valve from its seat, keeping the screw cap closed. The steam quickly permeates the plaster, and in five or ten minutes the temperature of the plaster is high enough to convert the water in it into steam. As soon as the plaster is thoroughly heated, shut off the steam by closing the valve, and raise the screw cap very slightly, to allow that in the chamber to escape slowly through the small aperture at the side of the screw. In a few moments the cast will be perfectly dry, the steam escaping from the chamber, carrying with it that generated from the moisture in the plaster. Extreme care should be taken that the steam shall escape *very slowly*, as otherwise the plaster may be blown out of the flask into the oven by the too rapid expansion of its vaporized moisture. The completion of the drying process is known by steam ceasing to be given off at the screw-cap, G. The drying may be facilitated by placing a small chip of wood between the two parts of the flask when it is put into the chamber, thus exposing a larger surface to the heat and allowing the moisture to escape readily.

" **Molding by Dry Heat.**—When the investment is dried, remove it from the chamber, insert and carefully adjust the selected blank; replace the flask in the oven immediately under the screws; see that the two sections are so placed that the guide-pins will enter properly into the lugs; open the screw-cap a turn or two to allow the escape of the gas from the hot box; turn down the large screw until it bears lightly upon the top of the flask, and close the machine. In less than five minutes the material will be sufficiently softened to permit the commencement of the molding. The screws will turn readily with the thumb and finger (using the smaller key-wrench), when the blank is properly softened. Close the flask gradually, stopping occasionally if the resistance is too great. Usually, if the temperature is about 300°, the flask can be closed in ten minutes; but if a very thick blank is used, the molding must proceed

slowly; the small screws may be used to advantage, and more time, say thirty minutes, may be consumed. As soon as the flask is closed—unless a lock flask is used—the flame should be extinguished, the door opened, and the machine allowed to cool. If a lock flask is used, it may be removed and thoroughly cooled before opening it, the oven being meanwhile ready for another case. The cooling may be accomplished rapidly, if necessary, by placing the flask in water. When perfectly cold, remove the plate from the investment; it will be found enveloped in the tin foil which had been burnished to the wax plate. Peel off the foil. The celluloid will present a hard, brightly-polished surface, received from its contact with the foil, and will need no further finishing than cutting off the excess of material and smoothing down the edges."

In the use of material, as a base for dentures, possessing properties so extremely sensitive to heat as that of celluloid, and so liable to suffer changes of color and structure materially affecting its usefulness by a misapplication of heat and faulty manipulation, everything that contributes to a better understanding of its behavior in the process of molding must be of interest and practical value. The following experiments of Dr. J. Stewart Spence, of San Francisco, Cal., throw some additional light upon the subject. He says: —

" Having just made more than thirty experiments with celluloid and the New Mode Heater, I have met with some interesting facts, of which, during two years' previous use of the apparatus, I was ignorant. The main results I will now give before relating the experiments, thus inverting the usual order of placing results last, for the sake of perspicuity.

" 1. Plaster investments require one and a half hours to dry in the oven of the heater, with the thermometer at 400°, and half an hour more to raise their heat to 320°. Drying them over a gas-burner takes nearly as long, and loosens the plaster from the flask. A thermometer placed between the slightly separated halves of the flask in the oven indicates when this heat is reached, at which time a blank, previously prepared, should be expeditiously inserted.

" 2. Celluloid may be molded in from five to ten minutes at

320°; in about twenty to twenty-five minutes it degenerates, becoming brown, hard, brittle and porous, and in twenty-five to thirty minutes it burns up.

"3. Celluloid will burn at either high or low temperatures, according to the length of time it is exposed to them, as well as their degree of heat. Thus it is unsafe to leave it at even a low heat for a long time, as in slow cooling.

"4. Celluloid is more liable to spoil if not under pressure, and those parts of the blank least subject to pressure are most liable to come out damaged. Therefore flasks should be closed with all expedition.

"5. Celluloid, unless worked at a high temperature, so as to flow readily, and with well-hardened plaster, will press the model out of shape and teeth out of position.

"6. Steam brought in contact with heated celluloid makes it puff up and degenerate.

"7. Plaster retains heat longer than metal, and therefore plates left in the oven to cool may spoil or burn up even when the temperature of the heater has fallen to a low degree.

"8. Tin foil discolors celluloid at a high heat, making it browner.

"9. Celluloid after molding is hardest at the surface, as may be clearly seen in a plate that has been slightly overheated, it being porous internally, but very hard on its surface.

"Instead of giving a copy of my record of these experiments, which would be unnecessarily prolix, I will give a condensed account of them by series.

"1st Series. *To test the heat of the oven.* I placed in the dry oven a separate thermometer, which, with the door closed, registered the same as that outside; then reversed them with similar results. Removing the central screw from the top did not reduce the temperature perceptibly. Removing the door reduced it a few degrees. Removing both door and screw caused a rapid decrease from 320° to 290°.

"2d Series. *To test the heat of oven with plaster in it.* I filled a half flask with plaster and placed it in the oven, with a thermometer on the floor beside it, of course closing the door, the outer thermometer standing at 320°. After twenty minutes the

inner thermometer had reached only 300°, showing the cooling effects of the plaster on the air of the oven. Moved the thermometer on to the plaster; the thermometer fell considerably, and while the outer thermometer rose in thirty minutes to 440°, the inner reached only 290°; steam was then admitted to the oven, and it ran instantly up to 340°; steam was then shut off, and the outer thermometer maintained at about 360° for thirty minutes longer, by which time the inner reached 320°. At this point some steam was let off, which ran the outer thermometer twenty degrees below the inner, showing that plaster is slow to part with its heat as well as to receive it.

"Further experiments were made in drying plaster, both in the oven, with steam and without it, and out of the oven over a gas-burner; also with plaster mixed with pulverized pumice and mixed with marble dust. It was found that in the oven with either steam or dry heat, and the outer thermometer at 400°, about thirty minutes were required to dry and heat a small half flask of plaster to 320°, and about two hours for a full flask. Done over a gas-burner, under an inverted flower-pot, a little less time was consumed, but the investments loosened from the flasks; under higher heats they become burnt and badly checked. Those mixed with pumice and marble dust took nearly as long to heat and became softer than the plaster alone, and so were thereafter abandoned.

"3d Series. *Testing celluloid in the oven without the presence of plaster, steam, or pressure.* A piece of celluloid placed in the oven at 320°, the heat rising, burned, after slight swelling, at 360°. A second piece remained in thirty minutes with the heat at 320°, swelled slightly, and crumbled to powder on being taken out. A third piece left in three minutes at 320° was taken out a little swollen and somewhat brittle and porous.

"4th Series. *Testing celluloid in the oven with plaster and with moisture.* A half flask of moist plaster was placed in the oven, and on it a piece of celluloid and a thermometer. The outer thermometer, starting from 320°, rose to 440°, and then fell to 360° in about sixty minutes, by which time the inner thermometer reached 320°, and the celluloid, after great swelling, ignited. (In the previous series of experiments the celluloid had swollen

but about one-tenth as much as it did in these.) Next a half flask of previously dried plaster was inserted, and the inner thermometer raised to 340°, when a piece of celluloid was dropped in, and burned in five minutes. A second piece at about 330° puffed up in ten minutes, and would probably have exploded in five more if I had not varied the experiment by admitting steam to test its effects, which were a greatly increased swelling and then gradual shriveling to a thin wafer. (That steam does not produce ignition was also demonstrated elsewhere, when its admission ran the inner thermometer up to 340°, and yet afterward, when the steam was shut off, the celluloid burned at 320°.) In the next test the dry half flask was again used, but the outer thermometer was lowered to 320°, which ran the inner one down much lower, but in forty minutes they tallied, during which forty minutes the celluloid after the first fifteen minutes began to puff, and in ten minutes more had reached full size, and then for fifteen minutes slowly shrank, then exploded.

"Both thermometers being now at 320°, a piece of blank was left in fifteen minutes, and on being taken out crumbled to powder under the slightest pressure. A second blank, in twenty-five minutes, at 300°, came out not crumbling so badly. A third at 280°, for thirty minutes, was slightly swelled and somewhat brittle and porous.

"5th Series. *Testing celluloid in the oven with pressure and plaster.* A full flask of plaster was placed in the oven, and its temperature raised to that of the outer thermometer, 320°; then a piece of celluloid was placed in the flask, which was closed down in three minutes, and in five more the piece was removed from the flask in perfect condition. A second piece was then inserted, closed in ten minutes, and removed from the oven, and in five minutes more opened in perfect condition. A third piece was left in twenty minutes, and in five more opened in perfect condition, not even discolored. A fourth piece was given twenty-five minutes in the oven and ten more before opening the flask with disastrous results; it had crumbled to a brown powder.

"This fifth series of tests show that the material in question remains perfect under pressure longer than without it. But it

is to be remembered that the investment here used must have lost some of its heat while out of the oven. Later trials seem to indicate *twenty minutes as the longest time that celluloid can safely be left at* 320°. As a side issue, the cohesion of the material was tested during this series; freshly-filed surfaces were placed together, and apparently joined, but they separated under a strong strain.

"6th Series. *Testing the effect of steam on the celluloid at* 320°. The same investment was used as in Series 5, and the flask closed in ten minutes, when steam was admitted. In ten minutes more the blank came out spoiled, being disintegrated, whitish and sticky. I have seen celluloid take on this soft and white condition when heated in water above 270°.

"7th Series. *Testing the flowing qualities of celluloid at* 320°. A piece of celluloid was placed in a flask heated to 320°, no cavity being left in the plaster to receive the celluloid. Closed in ten minutes. It sunk a bed for itself in the hard plaster, flowing but little. This is a hint as to the cause of misfits, raised bites, and thickened palates, of plates molded with soft plaster and low heats.

8th Series. *Testing the effects of quick closing.* A full blank was placed in a full flask of plaster heated to 320°, and closed so that the halves of the flask came together on one side considerably sooner than on the other. Gave it over fifteen minutes in the oven. When opened it showed, as expected, the side of the plate which had been the latest closed porous and brittle. As a side issue in this experiment, tin foil of two thicknesses, 18 and 60, were placed side by side on the blank, and when peeled off the surface below was of a browner color than the adjacent celluloid.

"I would hint at the possibility of the celluloid which oozes from the flask, and touches the wall of the oven, being ignited thereby in some instances. A deep excess-chamber should be cut around the model to prevent this. Moreover, this escaped celluloid, not being under pressure, is doubtless more liable to burn.

"Celluloid hardens on being subjected to dry heat, but much of this is not desirable, as its hardness is external, while inside

it becomes porous, and when thus hardened is very brittle. Celluloid will burn under water, as demonstrated in a vulcanizer, at 320°.

"Thin edges of celluloid will soften in hot drinks in the mouth. Thus, the festoons of gum left thin will shrink from the tooth, producing what may be termed a free edge of celluloid gum, under which dirt deposits, and shows through the semi-translucent celluloid. This is prevented by making the edges of the festoons of proper thickness. Another error frequently seen is that of cutting away the interdental celluloid gum (contrary to nature), thus forming cavities difficult to cleanse by the brush, producing unsightly discoloration at those points.

"The principal objection to celluloid is that after a year or two in the mouth it loses its beautiful color, and becomes of a dull vermilion shade, or even black. This will probably remain the chief objection to it. That it is not so tough nor so elastic as vulcanite, and that in consequence it wears away and loses its smooth surface in the mouth, and is unfitted for clasps, and that it is a little more difficult to work than rubber, would not prevent its popularity, if it were not for this discoloration. However, the loss of color does not always extend far into the plate, and much of it may be quickly removed with a brush-wheel and pumice."

Finishing.—This is accomplished with the use of the same instruments used in rubber cases. The final polish may be given first with pumice-stone, and afterward with whiting or Vienna lime. Dr. H. D. Knight, of Lancaster, Pa., recommends a polish obtained by rubbing with an old cloth wet with camphor. This may be valuable between teeth and in places inaccessible to the brush-wheel. In finishing, care should be taken not to heat the plate by friction, as by so doing the surface may be injured or the plate sprung out of shape.

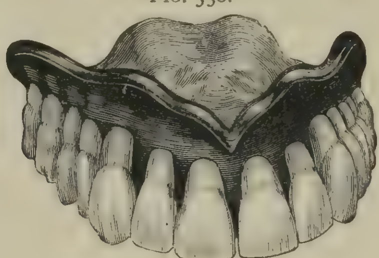
VULCANITE BASE-PLATE FACED WITH CELLULOID.

The above method of constructing an artificial denture, designated by the inventor as the "New Mode Continuous-Gum" process, provides for the use of single porcelain teeth without artificial gums, the latter being represented by the celluloid

facing. This expedient is most esteemed by those who regard rubber as a more suitable material for a base than celluloid, and who, in the use of the former, are unable to meet the requirements of a certain class of cases with either single gum teeth or sectional blocks.

In this combination work, which admits of an optional arrangement of each individual tooth, the conditions are secured which better enables the operator to effect such arrangement of the teeth as will best serve the purposes of mastication and aid in restoring the customary facial contour and expression of the individual. Still other advantages are claimed for this method, namely, that the rubber is stronger and more elastic, and, being harder, the pins are less liable to draw or loosen, while the same

FIG. 558.



property diminishes the liability to mechanical abrasion of the palatal surface in mastication, and, lastly, that in case of accident to the teeth they may be replaced with the use of celluloid, thus obviating entirely the necessity of revulcanizing, a process which always impairs the structural integrity of the rubber.

The first step in the process of constructing this kind of work consists in molding the rubber base-plate, with the teeth attached. All the preliminary processes, including the arrangement of the teeth, are the same as those practised when rubber alone is used. The teeth employed are those manufactured expressly for continuous-gum work and celluloid, as shown in Fig. 558. In waxing up the case, all the exterior surfaces of the teeth and marginal portions of the trial plate are left uncovered, and a strip of wax arranged all along the external border of the

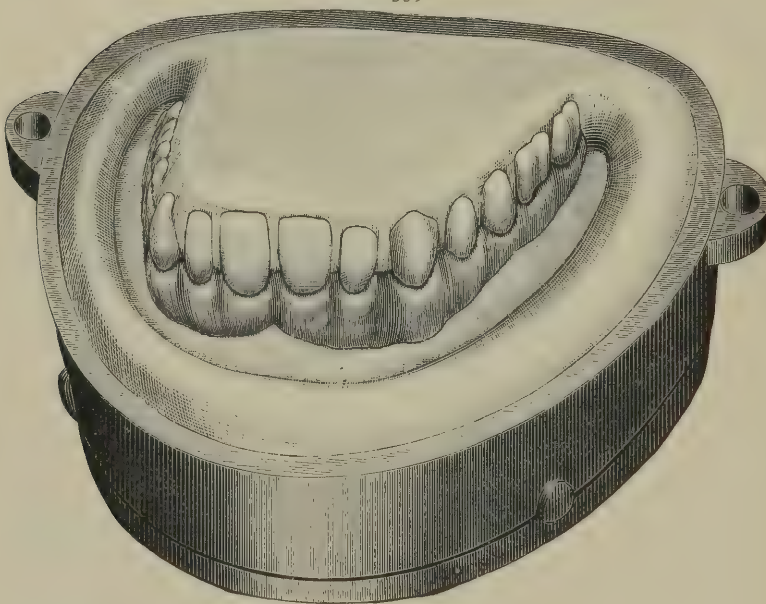
wax plate to form a groove for the celluloid, as shown in Fig. 558. The excavation thus formed exteriorly should extend inwardly into the interdental spaces far enough to secure anchorage for the celluloid in connection with that obtained by the grooved border. The space or spaces for the celluloid facing being thus provided for, the palatal portion is properly contoured, the case flasked, packed, and vulcanized in the usual manner. The piece, when removed from the flask, will exhibit an undercut groove along the border, and the external portions of the crowns and roots exposed in the manner shown in the illustration.

The second step in the operation consists in molding the celluloid facing. The following is the method of forming the matrix and molding the celluloid: Fill up all the space between the rimmed border of the plate and crowns of the teeth with wax and paraffin, as being preferable to wax alone, and then contour it exactly as required in the finished piece; cover with tin foil, and stipple the surface in the manner heretofore described. The case thus prepared is ready to be invested for the purpose of obtaining the matrix in which to mold the celluloid. In so doing, fill the lower section of the flask partly with plaster, and also the palatal portion of the plate, and then place the latter in the flask with the teeth upward, raising the front part of the plate somewhat, giving it a downward inclination posteriorly, in order that the upper section, when the investment is completed, may be detached without dragging. The plate should not be imbedded in the plaster beyond the grooved margin, making the line of separation on the outside along the border from heel to heel of the plate. Additional plaster is now poured in, covering the entire palatal face of the plate and crowns of the teeth, leaving only the outer portions of the latter and the plate exposed. When the plaster sets somewhat, pour in more plaster around the inner edge of the flask ring, forming a ridge, and also a corresponding groove or space between it and the plate. The piece thus invested will present the appearance shown in Fig. 559. The surface of the plaster is now varnished, and thin oil applied to all the surfaces. When the wax facing is covered with tin foil, the latter should not be oiled, as it is intended that this

shall adhere to the plaster when the flask is separated. The investment is now completed by adjusting the upper section of the flask and filling it with plaster. When sufficiently hard, the sections are carefully separated and the wax thoroughly removed with boiling water. The tin foil will remain adherent to the plaster in the upper section.

Select a celluloid blank of suitable size and saw off the outer rim, as shown in Fig. 560. Dress and carve this to near the size

FIG. 559.



and form of the space to be filled, having some excess of material. Having first softened the rim thus prepared by immersing it in boiling water for a few moments, remove, press it well into the space provided for it, and hold there until rigid. Place the two sections of the flask together in their proper relation, introduce into the oven previously heated, and close the flask in the usual way. When the piece is removed from the flask, and the tin foil removed by peeling it from the surface, to which it will adhere, little will be required in the way of finish-

ing except to remove surplus material at the necks of the teeth and borders of the plate, and final smoothing and polishing at these points. If the facing material has been stippled, the finished piece will present the appearence shown in Fig. 561.

FIG. 560.

The above process is also applicable to gold and cast metallic plates.

ZYLONITE.*

"A modified form of celluloid has been introduced under the name of *zylonite*, the working results of which appear to

FIG. 561.

show some difference in quality. Zylonite, like celluloid, is composed of pyroxylin and camphor, but in different proportions, being, it is claimed, a chemical combination, while celluloid is a mechanical mixture.

* Harris' "Principles and Practice of Dentistry."

" Possessing translucency, the effect of zylonite in the mouth is very pleasing, and, so far as it has been tested, promises to be more durable than celluloid, without the tendency to warp or to change color when ordinary care is taken in its manipulation, which is the same as for celluloid. The zylonite blanks are uniform in color, and although this material requires the same amount of pressure to mold, it flows with a more perfect sharpness of outline than celluloid, and apparently does not disintegrate."

CHAPTER XV.

ATTACHING PORCELAIN TEETH TO A METALLIC BASE WITH RUBBER OR CELLULOID.

The following method of attaching porcelain teeth to a metallic plate by means of rubber or celluloid, though but little practised heretofore, is attracting more attention than formerly, and is eminently deserving of more favorable consideration and general adoption, by reason of its conspicuous and acknowledged merits, than it has ever yet received. The credit of its first introduction to the notice of the profession is due to Dr. P. G. C. Hunt, of Indianapolis, Ind., who practised the method as early as 1859, and whose published descriptions of the manner of preparing the plate base, substantially the same as that for which Mr. S. D. Engle, of Hazleton, Pa., obtained letters-patent some years later, were given in the first edition of this work.

In commenting on this method, Professor Charles J. Essig very justly remarks that, by the means here indicated, we are "able to produce an artificial denture embracing all that is good in metallic and vulcanite work, at the same time avoiding the great defects of each."

That it possesses marked advantages over the method of attaching teeth to a metallic plate base by soldering is unquestionable. The waste and consequent change in the form of the plate incident to soldering, so inseparable from the older method of attachment by means of stays or backings, is wholly avoided; the strain upon the platina pins is greatly lessened by reason of the perfectly adapted rubber or celluloid socket in which each tooth or block securely rests; the liability to fracture of the teeth from concussion or violence is materially diminished on account of the pliable nature of the attaching material used; a near approximation to the natural form of the ridge or gum on the lingual side of the plate is secured; the rubber or celluloid, penetrating all the joints and openings between and beneath the

teeth, renders the piece wholly impervious to the oral secretions, making it, in point of cleanliness and purity, equal to continuous-gum work; the facility with which injury to the teeth may be repaired; the practicability of remodeling the piece without impairment of the teeth or plate; its susceptibility of receiving a final finish excelled by no other method in point of artistic beauty;—these are among the qualities which commend this method of substitution as one of peculiar merit and excellence.

In mounting teeth by this method, preference should be given to either gold, platinum, aluminum, or cast metal as a base. When silver is used, the plate should be made from refined silver alloyed with platinum, with the additional precaution of interposing a layer of tin foil between the rubber and plate, an expedient not necessary when celluloid is employed. Aluminum has a limited adaptability to this mode of substitution, but requires special treatment in its preparation for the purpose, a description of which will be given in connection with the manner of preparing the plate.

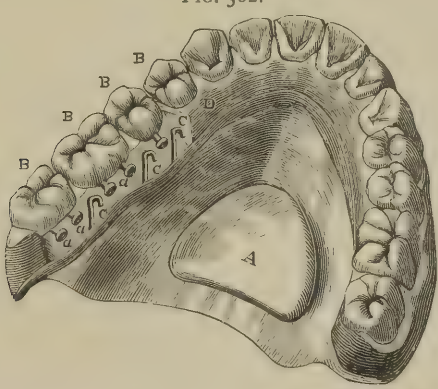
The manipulative details concerned in the construction of an artificial denture by the method under consideration are thus described by Dr. Hunt:—

"Take the impression, make metallic dies, and form the plate as for work in the ordinary way. After fitting the plate in the mouth, get the articulation, the fullness and length of the teeth, remove the wax and plate from the mouth, and make the plaster articulation. If a full set, after separating the articulation, and before removing the wax from the plate, take a small, light pair of dividers, set them say one inch apart, and with one point following the margin of the wax, representing the cutting edge of the teeth, and the other point marking permanently the plaster, you have always in the dividers so set a gauge for the length of any particular tooth. A convenient substitute for the dividers may be formed from a piece of wire of convenient length, one-half the diameter of a common excavator, by suitably twisting its middle for a handle, and its ends being sharpened, and pointing in the same direction, one or one and a half inches apart.

"Thus far we proceed as we do for ordinary gold work. We will now suppose the teeth ground and jointed, leaving as much

space between the teeth and plate as the plate will admit of. We next mark with a sharp-pointed instrument on the labial surface of the plate each point where it is necessary to place a loop for purposes hereinafter described. Then apply wax to the external or labial parts of the teeth and plate in any manner sufficient to retain the teeth in position, remove the wax from the lingual parts of the teeth and plate, and mark the position on the metal where it is desirable to insert loops, remove the teeth and wax, and with a small bow-drill make holes through the plate at the several points previously determined on for the attachments, about the size of the ordinary plate punch-hole, take a wire, or ordinary gold plate, cut in strips, say from a half to one line in

FIG. 562.



width, being governed by the amount of room there is under the base of the teeth, and with small, round-nosed pliers, bend the strip around, grasp both ends with square-nosed pliers, draw the round-nosed pliers from the loop, still grasping the square-nosed pliers with the left hand, and with a hammer strike the top of the loop a sufficient blow to keep the ends from springing apart. Cut off the ends, and dress down to fit the holes in the plate; after which solder on charcoal or other suitable substance without investment."

By reference to Fig. 562, which illustrates Mr. Engle's method of providing attachment for the rubber to the plate by means of bent or hooked wires soldered to the base, the substantial iden-

tity of Dr. Hunt's mode of forming loops for the same purpose will be apparent.

With this digression, we return to Dr. Hunt's instructions:—

"Pickle, dress, and polish that portion of the plate to be exposed to view. Bend and flatten the pins, arrange the teeth according to the articulation, waxing so as to cover up the loops if practicable; the loops should be placed as near the base of the teeth as possible, the rubber forming when finished a part of that general concave shape which is desirable in upper dentures, and which is not possible to obtain with the ordinary soldered work. Then with silicate of soda paint the joints, to keep the rubber from forcing in where it would show after vulcanizing. Flask, vulcanize, and finish up as usual. The advantages of this style of work are obvious. With this you have work as cleanly as the continuous gum, decidedly more so than the very best single gum or block-work soldered in the usual way; again, it is very much stronger, less liable to breakage, both in and out of the mouth, as the rubber gives *a perfect base* and support for the teeth to set upon. By this method *there is no springing of plates.* As your plate fits the mouth when the articulation was taken, so will be the fit when the case is completed.

"On the labial edge of the upper plate, the rubber may be allowed to project beyond the edge, if desirable, and it will be found in many cases exceedingly satisfactory to do so, and allow the rubber to be of considerable thickness near the alæ of the nose, where the loss of the cuspidati may leave a want of support to the soft parts adjacent, and which in this manner can be readily corrected. If the rubber extends upward so far as to irritate the muscular structure, a few minutes will be sufficient to make the necessary alterations. In all such cases where we have control of our patients, we place the denture in the mouth before finally polishing, so as to determine as accurately as possible the limit to which extension upward may be carried.

"The neatest work on this principle is made by carving blocks, giving to the lingual surface that regular concave form which is desirable. In this no platinum pins or loops are necessary, but in that half of the matrix on which the blocks are carved, large metallic pins are so arranged as to be hid from view in the tooth

body. Different-sized pins may be used, as large as the nature of the case will admit. In short, we make the holes in the block similar to those in pivot teeth, where there is not sufficient room in the block above the tooth (or below if an under) to allow the pins to run into the body of the teeth. After burning, grinding, and fitting, get the position of the holes in the blocks relative to the plate, and drill through the plate as before, and instead of loops, solder gold wire of suitable size and length, say a very little shorter than the depth of the hole in the blocks, and two-thirds the diameter thereof; the wire should have a screw-thread cut on it, or that which is just as good and more expeditious, barb or cut with a sharp knife. At this point of the manipulation, if it is desired that the rubber should extend beyond the labial or buccal edge of the metallic plate, place as many loops at different points as are sufficient to retain it with firmness, after which polish the plate, wax, and proceed as before described. If you desire no rubber beyond the blocks, the roughness of the holes in the same, and the barbed points on the gold wire when properly packed and vulcanized, will give ample strength and firmness to the case, and if care has been used in the entire manipulation, you will have, when finished, but a thin line of rubber exposed to view.

"In partial cases, if of gold base, solder on loops, as before, for the retention of the teeth, and if there are to be any clasps, make them of rubber, uniting them, as the teeth, with loops. If the ordinary plate teeth are used, it is frequently necessary to back them to give better retaining-points for the rubber. If blocks are to be burned, insert loops of platinum plate in the shape of the letter U in place of the platinum wire pins. In consequence of the affinity of the sulphur in the vulcanite for silver, plates of that metal should not be used."

Dr. A. S. Richmond, in the *Dental Cosmos*, recommends the following method of securing attachment of the vegetable plastics to the base-plate:—

"The method consists in punching the plate with holes with a punch devised for the purpose and herewith illustrated (Fig. 563), forming a number of depressions or pits in the palatal surface, which might be termed small air-chambers, and they certainly

assist materially as such, especially in lower dentures, where the holes are punched in a row on the outside and inside about one-fourth of an inch apart and one-eighth of an inch from the margin (Fig. 564). For upper dentures, where the undercut or recession of the maxillary ridge is so abrupt as to make it impossible to swage a plate to a proper fit, the plate can be trimmed to suit, making the upper portion of rubber, the perforation forming a firm attachment. I also send a three-quarter plate to show the method. There is no danger of springing the plate if proper care is used, and if by accident it should be out of shape, it is an easy matter to set it right by burnishing it upon the die.

FIG. 563.

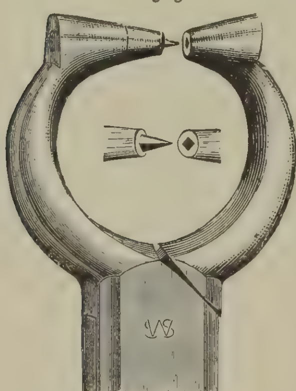
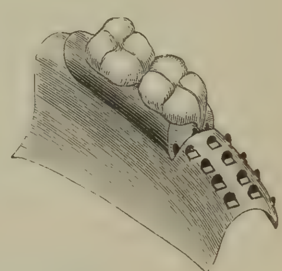


FIG. 564.



"I have used this method exclusively for a number of years, and have never had any objection offered by patients on account of the perforations.

"Dr. John H. Meyer, of this city, showed me some time ago a continuous-gum denture in which the entire surface of the plate was perforated with small holes, thereby reducing the weight of the metal about one-half, and making the most perfect attachment of the body, the perforations also assisting as small air-chambers."

The following unique and original method of casting a metal base-plate, fastenings and hooks, in a single piece, is thus described by Dr. Norman W. Kingsley: "The plate is formed of

a thin sheet of wax set up on the plaster model, but before it is flasked for casting I take a dozen small gimp tacks, with half round heads, and set them in a row upon the ridge of the lower jaw, with their heads just imbedded in the wax, and then flask the piece. In flasking it, I use plaster and sand, in the proportions of about three parts of sand to one of plaster. This gives a fine surface when it comes in contact with the wax in making the mold, and it is sufficiently porous to dry out quickly. When the flask is opened, the wax is readily removed; the tacks are pulled out, and when the casting is made the spaces that were occupied by the tacks are filled with the metal, so that we have a plate with a row of tacks of the same metal, which can be easily bent for attachments, standing around upon it."

If gum sections are used in connection with a plate formed in the manner just described, vulcanite may be employed as a means of attachment, but plain, single teeth are equally admissible in the use of either rubber or celluloid. The particular alloy used by Dr. Kingsley in casting plates, and of which he speaks in terms of high commendation, consists of pure tin and bismuth, in the proportion of one pound of the former to one ounce of the latter.

The following method of preparing aluminum plates for the attachment of the rubber was communicated to the author by Dr. J. W. Hollingsworth, of Greencastle, Indiana, an intelligent practitioner who has had long and extended practical experience in the various modes of working this metal for dental purposes, and who says of the following mode of procedure that "it is the most practicable and the most easily manipulated method that I have yet seen."

The following is the manner of preparing the plate as described by Dr. Hollingsworth: "Perforate the ridge of the plate at proper points and intervals; then pass through these perforations, from the inner surface of the plate, headed pins made of aluminum, which, after replacing the plate with the pins back upon the die, we shrink down to permanency with a hollow punch. The punch must be made with the hole not quite equal in depth to the length of the extruding portion of the pins and slightly bell-mouthed. The riveting process forms seriate

studs or pins, which may be bent or flattened with pliers in any way to suit the requirements of the case."

When celluloid is used for purposes of attachment in the case of full upper dentures, the palatal portion of the blank should be cut or sawed away, leaving only the ridge portion to be used, and this should be trimmed, if necessary, so as to have but little excess of material. The ordinary full blank may be used for lower cases, observing the same precautions in regard to quantity of material. When the blank is thus prepared, the subsequent manipulations are the same as those described in connection with the celluloid base.

It may be observed that, when rubber or celluloid is used, it is better to dispense with the plaster model in forming the mold or matrix, and proceed as follows: When the teeth are arranged, and the required contour and fullness given to the wax drafts, fill the lower section of the flask with plaster, and (having also filled the plate with the same) embed the plate in it, making the dividing line on the external rim of wax. When the plaster has hardened, and the other section formed, and the two afterward separated, the metallic plate will remain in the lower section and the teeth in the upper.

When using celluloid, plain teeth may be advantageously employed, the former representing the gum; this gives perfect freedom in the arrangement of each separate tooth in the denture, an optional disposition the importance of which cannot be over-estimated.

CHAPTER XVI.

CAST METAL BASE.

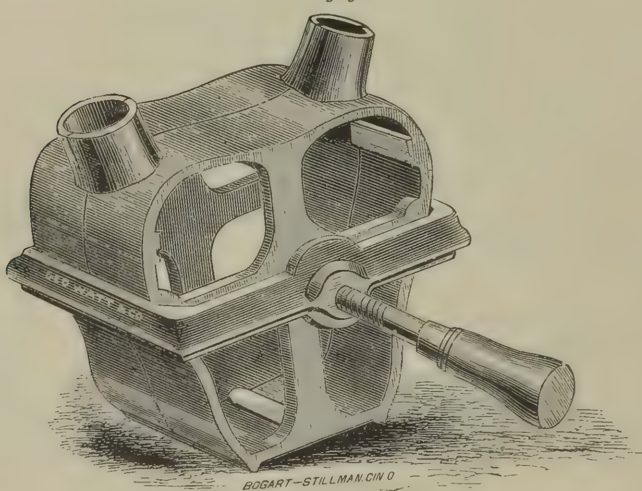
Cheoplastic Process.—The method of mounting artificial dentures by what is familiarly known as the "cheoplastic process," in which the base consists of certain metallic compounds or alloys in cast form, has comparatively but limited application in prosthetic practice. The method, as commonly practised, is rarely applied to full upper cases, occasionally to partial upper pieces, but chiefly to lower dentures in cases of unusual absorption of the alveolar ridge, requiring increased weight to secure adequate stability of the substitute. The alloys in most general use for this purpose are those compounded by Drs. Wood, Weston, and Watt, whose names are a sufficient guarantee of the suitableness of those several alloys for the purpose.

The construction of a denture by this method is readily accomplished by any one familiar with the working of vulcanite or celluloid. The manipulations concerned in the formation of a mold or matrix are, in general, the same as those employed in forming a matrix for rubber or celluloid. The model and investing material, however, must be of such substances as maintain their integrity of form perfectly under the heat necessarily applied in thorough drying of the case and contact of molten metals. Simple plaster, on this account, is unsuitable, either for the model or investment, and it is customary, therefore, to add to it, in relatively large proportions, such substances as undergo but little, if any, change of form when exposed to the necessary heat. Those most commonly employed are finely pulverized pumice-stone, marble-dust, soapstone powder, or clean white sand. In the use of either of these substances, only enough plaster should be added to give to the molding material sufficient body or strength necessary to provide against defacement in

handling, say one part plaster to three of sand, which is the mixture generally employed.

One of the best adapted flasks for molding and casting purposes, contrived by Prof. George Watt, is exhibited in Fig. 565. The piece, properly prepared by careful contouring of the wax or paraffin, is then flasked in the same manner as when preparing a mold for vulcanite. When the sections of the flask are separated, grooves or gateways should be cut, extending from the posterior and lateral margins of the mold to the openings on either side, shown in the figure, thus providing for the

Fig. 565.



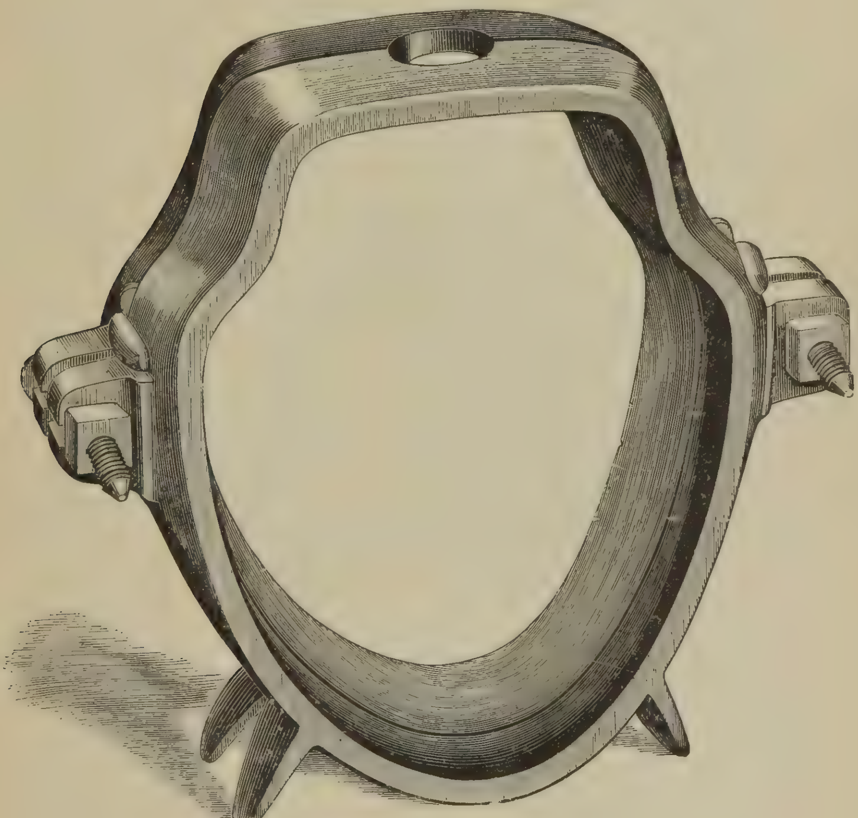
ingress and egress of the melted metal when poured; after which all traces of wax should be thoroughly washed out with boiling water.

The sections of the flask are now adjusted to each other, and tightly clamped, to prevent the escape of metal when poured. Before casting, the mold should be thoroughly dried by exposing it for two or three hours to an oven heat, and the temperature, at the moment of pouring, should be raised to about that required to fuse the alloys mentioned, or about 400° to 440° F.

In pouring the metal into the mold through one of the lateral

openings, the metal should rise freely and quickly into the opposite one, and if bubbling occurs, which will never happen if the plaster has been sufficiently dried, the flask should be lightly tapped on some hard surface until the ebullition ceases, thus insuring a more certain intrusion of the metal into all parts of the mold before solidification takes place.

FIG. 566.



Dr. Weston has devised a casting flask (Fig. 566), the two sections of which form an encircling band with the sides, or top and bottom, open, and which are closed securely with screw-bolts. This form facilitates the escape of moisture from the plaster investment in the process of drying.

When the piece is quite cold, it may be readily removed from the flask by soaking the investing material for a few minutes in water.

All superfluous metal is removed with suitable instruments, and all surfaces except the palatal face smoothed and polished, first with Scotch stone or fine emery cloth, and finally with chalk used upon a brush-wheel.

If there are any narrow spaces or interstices, not affecting the integrity of the plate, that are not completely filled at the time of casting, such imperfections, Dr. Kingsley suggests, may be readily and perfectly repaired with amalgam.

There are other practicable methods by which cast metallic plates may be utilized to advantage, and their application to the needs of the practitioner greatly extended. There are many cases of absorption in which a lower denture constructed entirely of cast metal would be objectionable on account of excessive weight. In such cases, a plate of sufficient thickness to secure the required stability may be cast, and the teeth subsequently attached with rubber or celluloid, as described in connection with swaged plates ; or the base-plate may be cast in the form of the rubber base described in connection with the New Mode Continuous-gum, and faced in the same manner with celluloid,—either method, while securing the requisite weight, admitting also of the use of single plain teeth.

GOLD ALLOY CAST BASE.

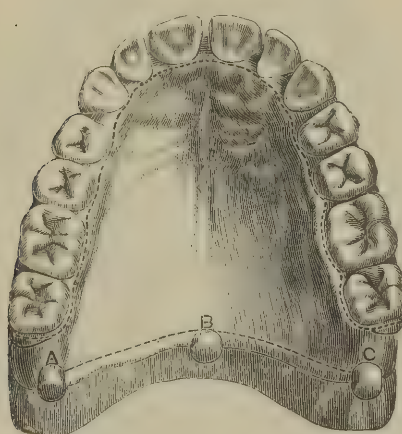
The compound of gold, silver, and tin, in varied proportions, in connection with specific and original methods of casting dental plates, devised and patented by Dr. George F. Reese, of Brooklyn, N. Y., has attracted attention as a possible substitute for the plastic vegetable substances so commonly employed as a base for artificial dentures.

After premising that the methods in common use for casting alloys were not applicable to one having the molecular properties of Reese's compound, the inventor says he was led, after multiplied experiments, to adopt the plan of which the following is a description :—

The impression is taken with plaster, to which salt or sulphate

of potassa has been added, and the model obtained from this with pure plaster. Upon this the teeth are arranged. For the trial plate, gutta percha, paraffin, and wax, or modeling compound, may be used. When satisfaction in the occlusion is obtained, then the case is returned to the model, and the waxing around the labial and buccal borders of the teeth completed. That portion of the trial plate which covers the palatine surface is now removed, so that the pins of the teeth will be nearly exposed, allowing the wax which is under the gum to remain. That the plate, after casting, shall not be too cumbrous, the trial

Fig. 567.

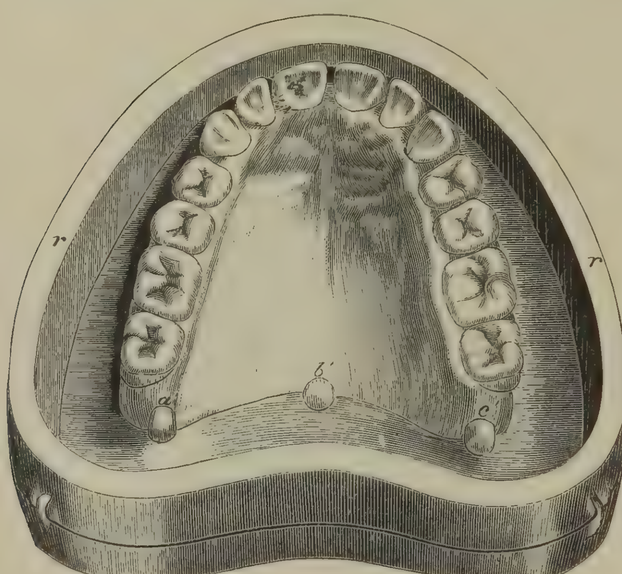


plate, which has been removed, must be substituted with two thicknesses of French flower wax, cut carefully to the model, and pressed down closely with the finger in a manner that no wrinkles will appear to mar the beauty of the work.

Fig. 567 represents a case thus prepared. The dotted lines show the borders of the thin wax. B, A, and C, represent nipples of solid wax, fixed to the posterior border and to the tuberosities, A and C being the places of exit for the molten metal into the waste pockets, and B the place of entrance of the metal from the pouring-gaine.

The case is now transferred to the small brass flask, *r*, Fig. 568, the sections of which have been well oiled upon the inner surface, to facilitate their removal from the investment. Either section is then placed upon a plate of glass and plaster poured into it until half filled. The model, as prepared, after being well saturated with water, is embedded in this single section, allowing the teeth and gums to remain uncovered. Set on the counterpart of the flask and add more plaster along the

FIG. 568.



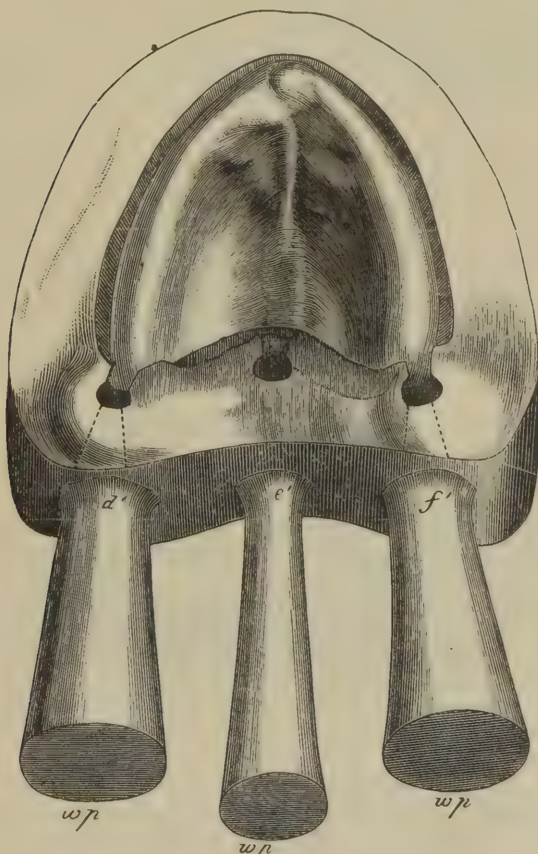
Case Ready for the Completion of Investment.

posterior border until the nipples are reached or slightly covered. After this has set, the upper section may be removed and the surface of the plaster covered with a thin varnish or soapy water. Return the section and complete the investment. Fig. 568 shows the case thus made ready.

After a proper time place the flask in hot water, that it may be separated without injury. When separated, wash away all the wax, and, by means of gentle tapping, remove the flask

rings from the investment and set them aside. The depressions formed by the nipples may now be extended through the plaster to the external edge; or, if the circumstances of the case make this impossible, the channels may be made at the line of division

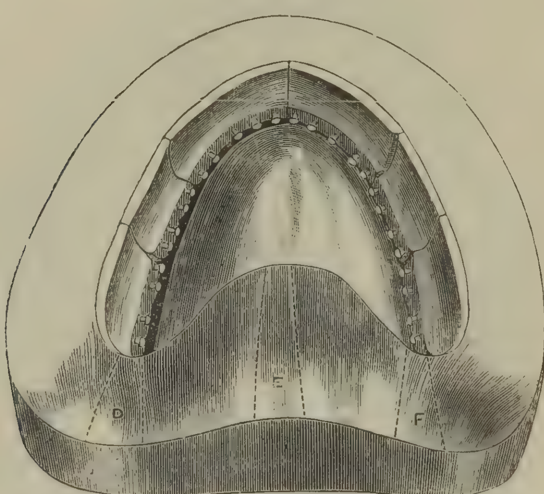
FIG. 569.



between the two sections, as shown by the dotted lines in Figs. 569 and 570. Externally, the channels, D, E, F, Fig. 570, should be neatly countersunk and varnished with shellac to receive the pockets. The latter are made of the French wax by warming and wrapping the same around a cone-shaped stick

and the base and apex of the cone neatly trimmed of all inequalities. These pockets should be about one and a half inches long, and about half an inch in diameter at the base, and an eighth of an inch at the apex. The pouring-gaine is made in the same manner, but should be smaller in diameter at the base and about two inches long. After removing these wax covers from the molding sticks, the larger ends of each should receive a thin wax cover secured to its place, and made water-tight by flowing hot wax along the line of junction, after the manner of soldering.

FIG. 570.



Upper or Counter Section corresponding to Fig. 569. D, E, F, channels for entrance and exit of metal.

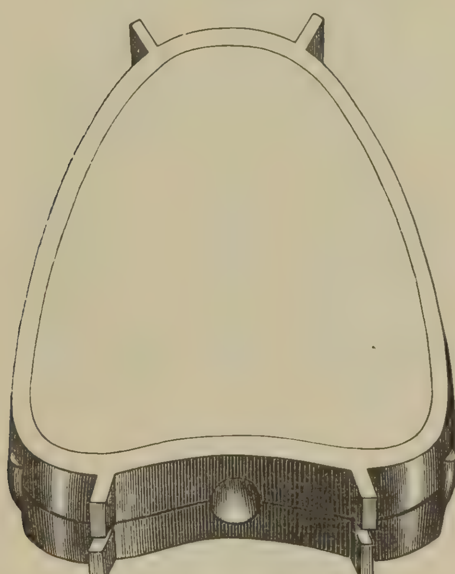
Trim the covers, then place the smallest ends of the large cones in the countersunk channels at the tuberosities and the small cone in the middle hole, and secure them with melted wax. Fig. 569, d', e', f', shows the pockets thus attached.

Should the channels have been made through the solid plaster of the lower section, as in Fig. 569, then the upper section, Fig. 570, need not be joined to it until after the pockets are secured to their places. Should, however, the channels have

been made upon the line of division, then the sections must be joined before the pockets can be attached.

The case is now ready for a second investment, which is done in a flask sufficiently large to embrace the case as it now presents. Fig. 571 represents the construction of the large flask. One section of the same is placed upon glass and about half filled with plaster. The case, having been well soaked with cold water, is laid carefully upon the plaster, allowing the long cone

FIG. 571.



to rest in the notch at the heel of the flask, and the waste pockets to become embedded in the plaster. Immediately put the other section of the flask in place and complete the investment by filling with plaster the uppermost section to fullness. Of course, there will be no division of the sections, as was the case in the former flasking. After solidification, the pouring-gaine must be neatly trimmed and countersunk, and great care must be exercised that no dirt be allowed to enter the channel.

The wax, which is embedded in the plaster, and which forms

the waste pockets, will be entirely absorbed, and no trace of it will be seen upon opening the flask.

All is now ready for drying. This is done in an oven specially prepared for the purpose, but it may be accomplished in any way to be chosen by the manipulator. An ice-cold mouth mirror placed over the opening of the pouring-gaine will detect the slightest moisture which may remain, and until this is entirely dispelled the casting should not be attempted.

There are several grades of the gold alloy, as compounded by Dr. Reese, to melt which requires a heat registering from 600° to 700° F., but a higher temperature than this must be attained before pouring, in order to secure a satisfactory flow. At 900° rapid oxidation takes place. This, of course, should be avoided. The alloy may be melted in an ordinary iron ladle or crucible, over a gas or other flame, and should be poured while the mold is hot.

After the lapse of an hour or two, or until the cast is sufficiently cooled to insure the integrity of the teeth, it may be placed in warm water, when the investment can be easily removed.

Fig. 572 represents the cast after removal. The surplus metal may be separated, along the dotted line S, with a ribbon saw, after which the denture is ready for the pumice wheel and brush. Fig. 573 represents the finished case.

Repairing.—The process of repairing broken plates is, in principle, the same as above. A flask, specially constructed by the inventor, is used for this purpose, whereby a single investment suffices. Suppose, for example, a plate is broken, from the labial to the posterior border, along the median line; the broken edges are scraped clean, and a separation made of about an eighth of an inch. The parts are then adjusted upon the model, and the space between the approximate edges filled with wax. At each extremity of the fissure a pencil of wax, an eighth of an inch in diameter, and one and a half inches long, is securely attached, perpendicularly, to the palatal surface, and the whole surrounded with plaster to the depth of one inch. Thus will be constituted two sections, which are separated, and the wax washed out. The external ends of the channels, formed by the pencils,

are then countersunk, and into each is inserted a wax cone, the one forming a pouring-gaine and the other a waste pocket. The

FIG. 572.

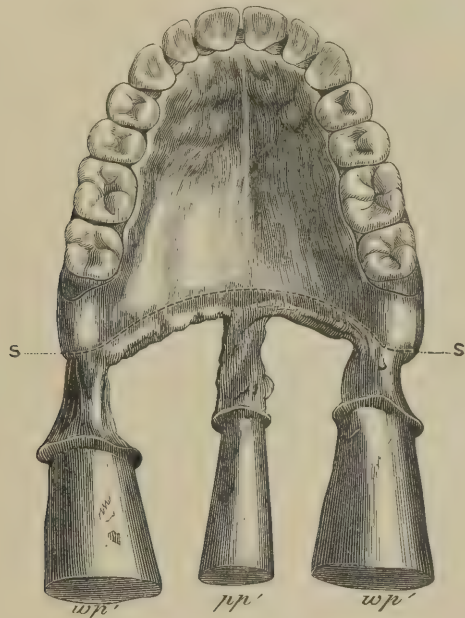
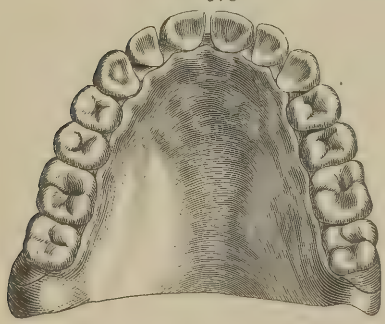


FIG. 573.



latter should be entirely covered by the plaster. The whole is now invested in the repair flask, and subsequently submitted to the process of drying.

Dr. W. S. Elliott, of New York, has taken advantage of the method above described to overcome the difficulties attending the construction of continuous-gum work.

To maintain a perfect adaptation of a swaged plate seems almost impossible, in consequence of the springing of the plate in the furnace. To avoid this difficulty, the following plan is suggested: The plaster model is first covered with two thicknesses of French flower wax, carefully adjusted. From this a metallic die and counter-die are made, and a very thin (No. 32) platina plate is swaged to fit the waxed model. The labial border need not be returned, as in ordinary cases. Upon this the teeth are arranged, and the case is transferred to the furnace for biscuiting and enameling. After proper annealing, it is replaced upon the model and waxed up, on the labial and buccal borders, over the edge of the plate, then flasked, the wax removed, and the metal cast upon it in the manner heretofore described.

Danger of checking the enamel is associated with the process; but success has attended the effort, and it is hoped that further experiments will insure perfect and uniform results.

CHAPTER XVII.

DEFECTS OF THE PALATAL ORGANS AND THEIR TREATMENT BY ARTIFICIAL MEANS.

Palatine Defects.—Defects of the palatine organs may be divided into two classes, viz., accidental and congenital. The first includes all loss of substance in either hard or soft palate by disease or otherwise. Such defects are not uniform in locality or extent, being sometimes but a simple perforation of the palate, and at others involving the destruction of the entire soft palate a considerable portion of the hard palate, the vomer and turbinated bones, and the loss of the teeth.

The second class includes all malformations, from the simple division of the uvula to an opening through the velum, palatine and maxillary bones, and a division of the upper lip, thus uniting throughout their entire extent the nasal passages with the oral cavity.

These malformations are quite similar in character, but not uniform in extent. They may be said to begin with the uvula, and in the uvula and velum *always occupy the median line;* but as the defect progresses anteriorly, it may deflect to one side or the other of the vomer, and follow the nasal passage through the lips, leaving the vomer articulated with the palate bone on one side; while in other cases the deformity seems to follow the median line, and thus involves both nasal passages and terminates in a double fissure of the lip.

In both classes (accidental and congenital) the faculty of distinct articulate speech is seriously impaired by defects of any extent. In ordinary cases of congenital deformity, deglutition is not materially interfered with. The patient, having never known any other method of swallowing, is not conscious of any difficulty. Accidental lesions, however, coming generally in adult life, produce, in this respect, very great inconvenience.

The remedy for these evils must be the closing of the abnormal passage by some means which will restore the functions to the deformed organs. In perforations of the hard palate, unless of extraordinary extent, the method is very simple. In the loss of the soft palate by disease the remedy is more difficult, and in extensive congenital deformity still more complicated appliances will be required.

As we have classified the defects, we shall also classify the appliances used for their remedy.

The term *obturator* will be used for all appliances intended to stop a passage, or all openings in the hard or soft palate which have a complete boundary. Appliances made to supply the loss of the posterior soft palate, whether accidental or congenital, will be called artificial vela, or palates.

Obturators.—Any unnatural opening from the oral cavity into the nasal cavity, which will permit the free passage of the breath, will impair articulation. Any appliance which will close such passage, and can be worn without inconvenience, will restore articulation.* Obturators were formerly made of metallic plate, gold or silver being most commonly employed, and many very ingenious pieces of mechanism were the result of such efforts, but latterly vulcanized rubber has almost entirely superseded the use of metals. Vulcanite has been found preferable to metals, being much lighter and much more easily formed and adapted, particularly when of peculiar shape.

The steps to be taken in the formation of an obturator are not unlike those used in making a base for artificial teeth. It is essential that an accurate model be obtained of the opening, the adjacent palatal surface, and the teeth, if any remain in the jaw. For this purpose an impression in plaster is the only reliable means for such an end. Care must be used that a surplus of plaster is not forced through the opening, thus preventing the withdrawal of the impression by an accumulated and hardened

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* The student will bear in mind that no cognizance is here taken of openings similar to those described in cases of congenital fissure, where the surgeon has united the soft palate, and left an opening through the hard palate, to be covered by an obturator. In such cases, neither the surgeon's operation nor the obturator will prove of any material advantage.

mass larger than the opening through which it passed. To avoid this, beginners or timid operators had better take an impression in the usual manner with wax; if this is forced through, it can be easily removed, without injury to the patient. From this wax impression make a plaster model, and upon this form an impression-cup of sheet gutta-percha, with a stick, piece of wire, strip of metal, or any other convenient thing for a handle. This extemporized impression-cup must not impinge upon the borders of the opening, neither should it enter to any extent. With a uniform film of soft plaster of from one-sixteenth to one-eighth of an inch in thickness laid over this cup, a correct impression can be made without any surplus to give anxiety. Upon a correct plaster cast, taken from such an impression, make a model of the obturator out of gutta-percha, thin sheets of modeling compound, or other plastic substance; the subsequent steps being in principle the same as in making any other piece of vulcanite. It is desirable that it should enter the perforation and restore as far as possible the lost portion of the palate, but it must not protrude into or in any way obstruct the nasal passage.

The entire freedom of the nasal passage is essential to the purity of articulation.

That portion of the obturator which occupies the oral cavity should be made as delicate as possible, consistent with its strength and durability.

A clumsy contrivance will interfere with articulation almost as much as it is improved by stopping the opening; therefore, if the obturator could be confined entirely to the opening, like a cork in a bottle, it would be all the more desirable, but as it cannot, resort must be made to clasping to the contiguous teeth, if there are any, and if not, the obturator must spread out over the whole jaw, and receive its support in the same manner as would a set of artificial teeth. In fact, this is just what it would become in such a case, viz., an upper set of teeth bridging over and filling up an opening in the palate, thus combining an obturator with a set of teeth.

Kingsley's Obturators and Methods of Procedure.—The following descriptions, with accompanying illustrations,

were contributed to this work by Professor Norman W. Kingsley, who excels in the practice of this difficult and important specialty of the Dental Art. The doctor writes as follows:—

Fig. 574 represents an obturator without teeth and without clasps, for a perforation of the hard palate, being sustained *in situ* by impinging upon the natural teeth with which it comes it contact. Accuracy of adaptation and delicacy in form are all that is essential in such cases, and the restoration of the speech will follow immediately.

Fig. 575 represents a more complicated obturator, adapted to an opening in the soft palate.

The necessity for a variation in the plan will be found in the anatomical fact of the constant muscular action of the soft palate, which would not permit, without irritation, the presence of an immovable fixture.

FIG. 574.

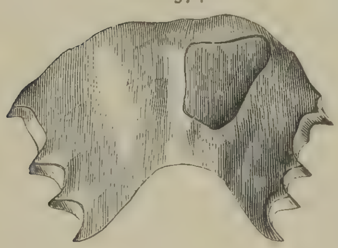
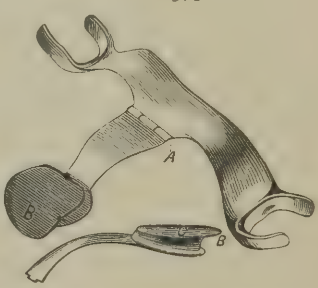


FIG. 575.



This is contrived, therefore, with a joint that will permit the part attached to the teeth to remain stationary, while the obturator proper is carried up or down as moved by the muscles. The joint, *A*, should occupy the position of the junction of the hard and soft palates. The joint and principal part of the appliance is made of gold, the obturator of vulcanite. The projection, *B*, lies like a flange upon the superior surface of the palate and sustains it; otherwise the mobility of the joint would allow it to drop out of the opening. This flange is better seen in the side view marked *C*. It is readily placed in position by entering the obturator first, and carrying the clasps to the teeth subsequently.

Figures 574 and 575 will illustrate the essential principles involved in all obturators. The ingenuity of the dentist will often be taxed in their application, as the cases requiring such appliances all vary in form and magnitude.

Artificial Palates.—Before proceeding to a description of appliances, a brief reference to the anatomical relations and functions of the palate will be necessary. The palate exercises quite as important an office in the articulation of the voice as does the tongue or lips. Being a muscular and movable partition to separate the nasal and oral cavities, one edge is attached to the border of the hard palate, while the other vibrates between the pharynx and the tongue. The voice, therefore, as it issues from the larynx, is directed by the palate entirely into the mouth, or through the nose, or permitted to pass both ways.

A very slight deviation in this organ from its natural form will make the voice give a different sound. So will, also, the presence of anything that clogs the natural passages, either oral or nasal.

Place any obstruction in the nasal passages, paralyze the soft palate, or let it be deficient in size, and the power of distinct articulation is wanting.

The evidence of this statement is frequently found after the surgeon has successfully performed the operation of staphylorraphy in cases of congenital fissure.

In such instances (with rare exceptions) the newly-formed palate is so deficient in length, and so tense, as to be deprived of its function. It cannot be raised so as to meet the pharynx and shut off the nasal passage, but hangs like an immovable septum to divide the column of sound.

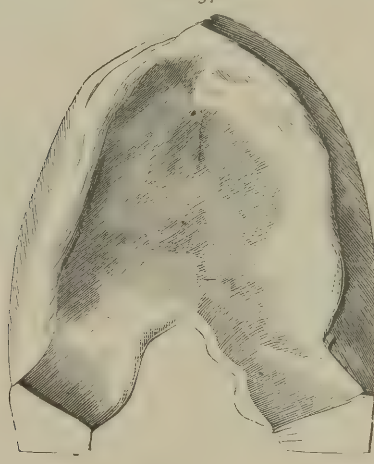
Fig. 576 represents a defective palate belonging to the first class, the uvula and a portion of the soft palate contiguous being destroyed by disease. In such a case an obturator would be useless; the constant activity and the surrounding parts would not tolerate it. The material used for a substitute must be soft, flexible, and elastic, and the elastic vulcanite is admirably adapted to this purpose.

By observing the cut (Fig. 576) it will be seen that a portion of the soft palate along the median line remains, and consequently

there will be considerable muscular movement which must be provided for, and which may be taken advantage of. It is desirable to make this movement available in using an artificial palate, as thereby more delicate sounds are produced than otherwise.

This case presents some extraordinary difficulties in the fact that all the teeth of the upper jaw have been extracted, and it was necessary, therefore, to adapt a plate which should not only sustain teeth for mastication, but bear the additional responsibility of supporting the artificial palate. In the choice of material best adapted for the base for the teeth in such instances, it

FIG. 576.



is preferable to adopt that which will prove the most durable. There are too many interests involved to risk the adoption of anything but the best. In the case under description, the patient desired duplicates, and two sets of teeth were made, one on gold and the other on platina with continuous gum.

The plates were made like other sets of teeth, with the exception of a groove located on the median line at the posterior edge to receive the attachment for the palate (marked C, in Fig. 577).

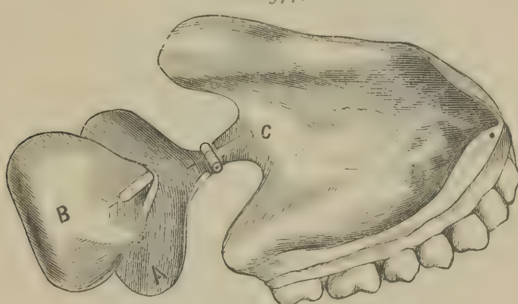
Fig. 577 will indicate the set of teeth with palate attached. The wings marked letters A and B are made of soft rubber; the frame to support them is made of gold, with a joint to provide

for the perpendicular motion of the natural palate, as in the case of the obturator represented in Fig. 575.

When the artificial palate is in use, the joint and frame immediately contiguous lie close to the roof of the mouth; the rubber wing, letter A, bridges across the opening on the inferior surface or side next the tongue; the wing, letter B, bridges across the opening on the superior or nasal surface, and is also prolonged backward until it nearly touches the muscles of the pharynx when they are in repose.

Both these wings reach beyond the boundary of the opening and rest on the surface of the soft palate for a distance of from one-eighth to one-quarter of an inch, thus embracing the entire free edge of the soft palate. This last provision enables the

FIG. 577.



natural palate to carry the artificial palate up or down, as articulation may require.

When the organs of speech are in repose, there is an opening behind the palate sufficient for respiration through the nares. When these organs are in action, a slight elevation of the palate, or a contraction of the pharynx, will entirely close the nasal passage and direct all the voice through the mouth. The palate thus becomes a valve to open or close the nares, and to be tolerated must be made with thin and delicate edges which will yield upon pressure. An instrument thus made will restore, as far as is possible by mechanism, the functions of the natural organ.

In the case under description, the patient was a lady; the

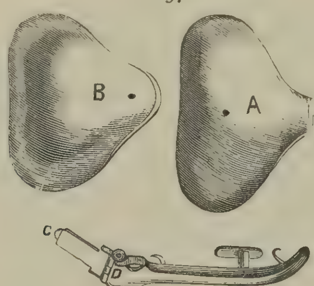
defect had existed for seven years before remedy. Articulation was very defective; distinct and perfect articulation followed within one month.

Fig. 578 represents the artificial palate separated into its constituent parts. The frame is bent at the joint, in the engraving, to show a stop, marked D, which prevents the appliance from dropping out of position. Letter C shows the tongue, which enters the groove in the plate of teeth and connects them. Letters A and B are the rubber flaps, which are secured to the frame by the hooks as seen in the engraving.

The process for making the rubber wings will be found described on page 640.

Fig. 579 shows a more extensive palatine defect of the first

FIG. 578.



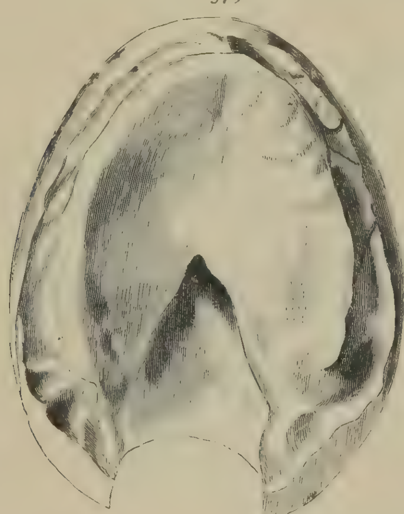
class. In this case the entire soft palate is gone, together with a small portion of the hard palate at the median line.

Although this defect is greater in extent, the means for its remedy are more simple. The muscles of the palate are entirely gone, and consequently no perpendicular movement need be provided for.

The appliance in this case will resemble an elastic obturator more than the valve-like palate of the preceding one. The principle here adopted will be substantially that recommended by Mr. Sercombe, of London, some ten years since, and consists of a plate with a set of teeth in the usual form, and attached to its posterior edge an apron of soft rubber, which shall bridge the opening on its inferior surface, extending nearly to the pharynx. Fig. 580 represents the set of teeth with the palate

attached. In Mr. Sercombe's appliance this apron was made of the common sheet rubber in the market, prepared for other uses, and is objectionable for two reasons: 1st, a want of purity in the materials of which it is compounded, in many instances substances being used in its manufacture which would prove deleterious to the health of the patient; and, 2d, its uniformity of thickness. It is far preferable, therefore, to make a mold which will produce a palate of pure and harmless materials, and which shall be of sufficient thickness in the central part, and at its anterior edge, to give it stability, and shall have a thin

Fig. 579.



and delicate boundary wherever it comes in contact with movable tissue. Such a palate may be made in a mold by substantially the same process as hereinafter described. (See page 640.) It may be secured to the plate by a variety of simple means. One, which will give as little trouble to the patient as any other, is to make a series of small holes along the edge of the plate and stitch it on with silk, or fine platina, gold, or silver wire may be used.

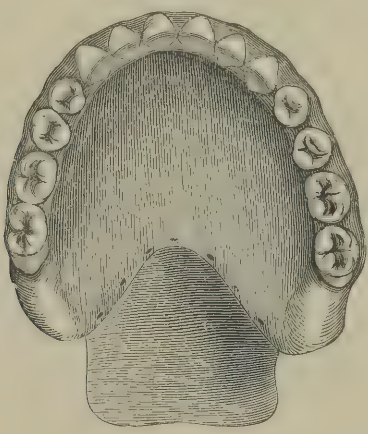
It is desirable to have the plate and palate present a uniform surface on the lingual side. In fitting the plate, therefore, it

may be raised along the posterior edge from the sixteenth to the tenth of an inch, according to the thickness of palate desired. The rubber will thus be placed on the palatine surface of the plate and present uniformity on the lingual surface.

A little thought will show that in this case the patient must educate the *muscles of the pharynx alone* to do the work of shutting off the nares, which in the former case was performed by them in conjunction with the muscles of the palate. Perfection of articulation will therefore depend upon the success of the patient in this new use of these muscles.

In cases of accidental lesions of the palate, such as are under

Fig. 580.



consideration, this education of the muscles to a new work will not be difficult. The patient at some former time has had the power of distinct articulation; his ear has recognized in his own voice the contrast between his present and former condition; the ear will therefore direct and criticise the practice until the result is attained.

In the case illustrated by Figs. 579 and 580, the defect had existed for twenty-eight years, the patient at the time of the introduction of the artificial palate being nearly fifty years of age. The effect upon the speech was instantaneous. Articulation was immediately nearly as distinct as in youth, and this

remarkable distinctness can only be accounted for upon the assumption that the pharyngeal muscles had undergone a thorough training in the vain effort to articulate without any palate.*

The two cases chosen to illustrate the application of artificial palates in accidental lesion have required, as will have been perceived, entire upper sets of artificial teeth in connection with the palates. This selection was purposely made, because the difficulties to be overcome are much greater. In cases where there are natural teeth remaining in the upper jaw, the palate and its connection with a plate would be substantially the same, and the plate might easily be secured to the teeth by clasps, in the same manner as a partial denture.

Artificial Palates for Congenital Fissure.—Congenital fissure of the palate presents far greater difficulties to be overcome than cases of accidental lesion. The opening is commonly more extensive, the appliance more complicated, and the result more problematical. Nevertheless, appliances have been made in a large number of cases, which have enabled the wearer to articulate with entire distinctness, so much so as not in the least to betray the defect. The first efforts in this direction were of the character of obturators, simply plugs to close the posterior nares, and the results were far from satisfactory. It was not until it was recognized that the two classes of cases (accidental and congenital) were entirely distinct that much progress was made.

Nearly every case of accidental lesion can be treated with an obturator with considerable success; very rarely will an obturator be of any benefit in congenital fissure, even if the congenital and accidental case present substantially the same form of opening. For this reason so much mystification has been thrown around these appliances within a few years past. The character of the different classes has been confounded, and an instrument admirably adapted to one class has had claimed for it an equal application to the other class. Let it be understood, therefore,

* An account of this case appears in the *Argus*, of Bainbridge, Georgia, August 1, 1868, written by the patient himself, the editor of that paper.

as a rule to which there will be but few exceptions, that congenital fissure of the soft palate requires for its successful remedy a soft, elastic, and movable appliance, and that when the most skilfully made and adapted instrument is worn, *articulation must be learned*, like any other accomplishment. Various inventions have been made for this purpose within the last twenty-five years, from the most complicated one of Mr. Stearns, described in the first edition of this work, to the extreme of simplicity of bridging the gap with a simple flap of rubber. The Stearns instrument, with all its complexity, embodied the only true prin-

Fig. 581.

ciple, viz., the rendering available the muscles of the natural palate to control the movements of the artificial palate.

The essential requisites of an artificial palate will be to restore, as far as possible, the natural form to the defective organs with such material as shall restore their functions. Muscular power, certainly, cannot be given to a piece of mechanism, but the material and form may be such that it will yield to and be under the control of the muscles surrounding it, and thus measurably bestow upon it the function of the organ which it represents.

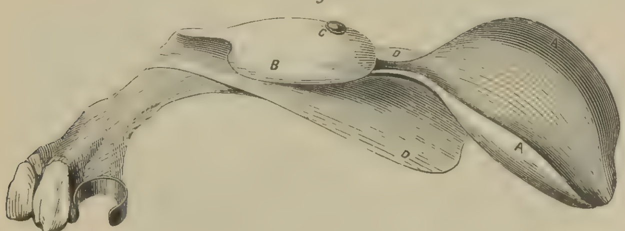
Fig. 581 represents a model of a fissured palate, complicated with hare-lip on the left side of the mesial line. There is a divi-

sion, also, of the maxilla and the alveolar process, the sides being covered with mucous membrane, which come in contact with each other but are not united. The left lateral incisor and left canine tooth are not developed.

Fig. 582 represents the artificial velum, as viewed from its superior surface, together with the attachment and two artificial teeth to fill the vacancy.

The lettered portion of this appliance is made of elastic vulcanized rubber; its attachment to the teeth of hard vulcanized rubber, to which the velum is connected by a stout gold pin firmly embedded at one end in the hard rubber plate. The other end has a head, marked C, which, being considerably larger than the pin, and also the corresponding hole in the velum, it is forced through,—the elasticity of the velum permitting,—and the two are securely connected.

FIG. 582.



The process, B, laps over the superior surface of the maxilla (the floor of the naris), and effectually prevents all inclination to droop.

The wings, A A, reach across the pharnyx, at the base of the chamber of the pharnyx, behind the remnant of the natural velum.

The wings, D D, rest upon the opposite or anterior surface of the soft palate.

Fig. 583 represents a model, the same as Fig. 581, with the appliance, Fig. 582, *in situ.*

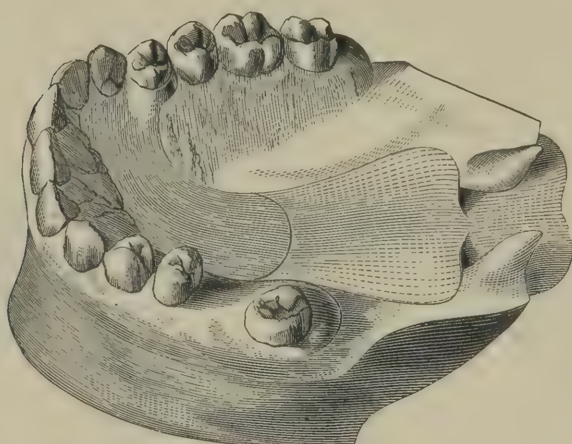
The wing, D D, in Fig. 582, and the posterior end of the artificial velum only in this cut being visible.

Method of Making an Artificial Palate.—The success of

these appliances depends very much upon the accuracy of the model obtained to work by.

It is essential that the entire border of the fissure from the apex to the uvula should be perfectly represented in the model, as the parts are when in repose. It is also necessary that the model show definitely the form of the cavity above, and on either side of the opening through the hard palate, being that part of the cavity which is hidden from the eye. It is desirable, also, that the posterior surface of the remains of the soft palate be shown, but this is not essential ; but it is especially important

FIG. 583.



that the anterior or under surface be represented with relaxed muscles and in perfect repose. The impression for such a model must be taken in plaster ; it is the only material now in use adapted to the purpose. An ordinary Britannia impression-cup may be used, selecting one in size and form corresponding to the general contour of the jaw. This cup will be found too short at the posterior edge to receive the soft palate, but it may be extended by the addition of a piece of sheet gutta-percha, which must be molded into such form as not to impinge upon the soft palate, but which will reach under and beyond the uvula, and thus protect the throat from the droppings of plaster. Before

using the plaster the posterior edge of the gutta-percha extension may be softened by heat and introduced into the mouth; contact with the soft palate will cause it to yield, so that there is no danger of its forcing away the soft tissues when the plaster is used. With the precaution not to use too much plaster, the first effort will be to get only the lingual surface. After trial, if the impression show definitely the entire border of the fissure, and the soft palate has not been pushed up by contact with the cup, nor pulled up by the spasmodic action of the levator muscles, it is all that is thus far desired. If, however, the soft parts have been disturbed (which on close comparison a little experience will decide), it is better to cast a model into the impression, and upon this model extemporize an impression-cup as described on page 629. This temporary cup will have the advantage of the former, insomuch that it will require but a film of plaster to accomplish the result, thus lessening the danger of disturbing the soft tissues. After the removal, if it is seen that any surplus has projected through the fissure and lapped out to the floor of the nares, it may be pared off.

The next step will be to obtain, in conjunction with this impression of the under surface, which we will call the palatal impression, an impression of the upper or nasal surface of the hard palate.

This can be done by filling the cavity above the roof of the mouth with soft plaster down to the border of the fissure, and while yet very soft carrying immediately the palatal impression against it, and retaining it in that position until the plaster is hard, which can easily be ascertained by the remains in the vessel from which it was taken. With the precaution to paint the surface of the palatal impression with a solution of soap, to prevent the two masses from adhering when brought in contact, there will be no difficulty in removing it from the mouth, leaving the mass which forms the nasal portion *in situ*. With a suitable pair of tweezers this mass is easily carried backward and withdrawn from the mouth, and the irregular surface of contact indicates its relation to its fellow when brought together.

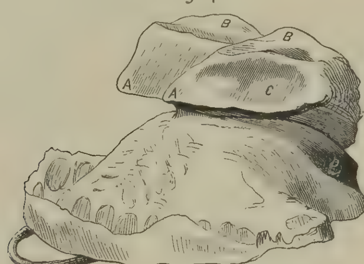
Fig. 584 will show such an impression. The portion marked A, B, C, will readily be distinguished as that which entered the

nasal cavity. The line of separation from the palatal impression is plainly indicated in the engraving. The groove, marked D, shows clearly the impression made by the delicate uvula in the soft plaster. The nasal portion is relatively large, showing an unusually large nasal cavity.

The vomer lies between the projections marked A A, these projections entering the nasal passages. The surfaces marked B B come in contact with the middle turbinated bones, the surface marked C in contact with the inferior turbinated bone. In many instances these turbinated bones are so large as to nearly fill the nasal passages.

The method of obtaining the model of the jaw from the impression does not require any particular description. The

Fig. 584.



process is similar to the making of a cast into any other mouth impression.

The model represented in Fig. 581 shows a convenient form for such a cast.

When the nasal portion of the impression does not indicate the superior surface of the soft palate, the part may be represented in the cast by carving. It is not essential to the success of the instrument to be made that the posterior surface of the soft palate should be represented with the same accuracy that is required of the inferior surface, or of both surfaces of the hard palate. By the aid of a small mirror and a blunt probe, the thickness of the velum and the depth behind the fissure can be ascertained and the model carved accordingly.

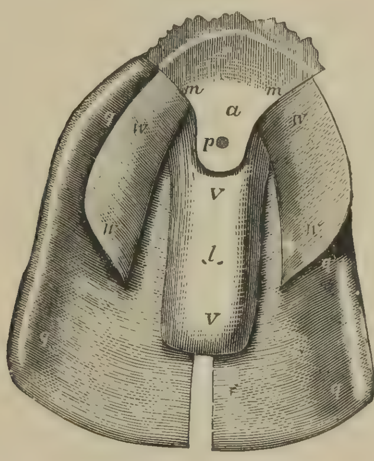
The portion of the artificial palate coming in contact with it is

so elastic that it easily adapts itself to a slight inequality, rendering absolute accuracy less important.

The next step will be the formation of a model or pattern of the palate. Sheet gutta-percha is preferable for this purpose, although wax, or many other plastic substances, might answer.

The form which should be given it is better indicated by the drawing, Figs. 582 and 589, than a written description would give. The Stearns instrument, of which cuts are here given (Figs. 585, 586), was made to embrace the edges of the fissure, and was slit up through the middle, so that when the edges of

FIG. 585.

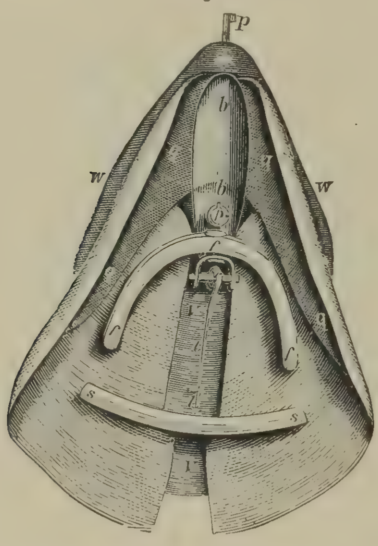


the fissure approach each other, as they always do in swallowing, the two halves of the instrument would slide by each other, and a third flap or tongue was made and supported by a gold spring to cover and keep closed this central slit. This complicated provision for the contraction of the fissure is entirely superseded in Figs. 582 and 589, by making the instrument somewhat in the form of two leaves, one to lie on the inferior and the other upon the superior surface of the palate, and joined together along the median line. When the fissure contracts, the halves of the divided uvula slide toward each other between these two leaves. The posterior portion, marked A in Fig. 582,

is made very thin and delicate on all its edges, as it occupies the chamber of the pharynx and is subject to constant muscular movement.

The sides are rolled slightly upward while the posterior end is curved downward. The inferior portion, marked D D, in Fig. 582, should reach only to the base of the uvula, and bridge directly across the chasm at this point, and no effort to imitate the uvula should be made. The extreme posterior end should not reach the posterior wall of the pharynx when all the

FIG. 586.



muscles are relaxed by a quarter of an inch, although subsequent use must determine whether this space be increased or diminished, thus leaving abundant room for respiration and the passage of nasal sounds. In cases where it is desirable to make the instrument independent of the teeth, so far as possible, in its support, the anterior part, which occupies the apex of the fissure in the hard palate may lap over on to the floor of one or both nares. Such a projection is seen in Fig. 582, marked B, and a like process is seen in Fig. 589, but not lettered. Were it not for this process in this case, the palate would drop out of

the fissure into the mouth, the single clasp at the extreme anterior end not being sufficient to keep the whole appliance in place throughout its entire length. Caution must be exercised that this projection entering the nares be not too large, or it will obstruct the passage and give a disagreeable nasal tone to the voice.

All these described peculiarities must be provided for in the gutta-percha model, which, after having been carefully formed to the cast, may be tried in the mouth to ascertain its length or necessary variations. When its ultimate form has been decided upon, provision must be made to duplicate it in soft rubber.

A parallel process, and one which will be a familiar illustration, is used when a set of teeth is made on vulcanite base. A model or pattern form is made of gutta-percha, bearing the teeth, and in all its prominent characteristics is shaped as the completed denture is desired, the rubber duplicate being vulcanized in a plaster mold. In like manner the rubber duplicate of the palate, as before described, may be made in a plaster mold.

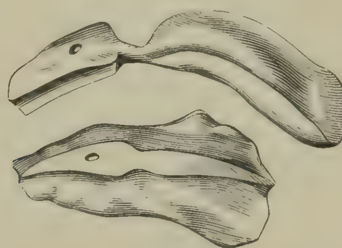
If plaster is used it must be worked with much care, so that the surface shall be free from air bubbles, or the rubber palate will be covered with excrescences that cannot be readily removed. By covering the surface of the mold with collodion or liquid silex, it will be much improved. But ordinarily plaster molds will be found too troublesome for general use. They may be put to a most excellent use, however, by using one to make a duplicate of the gutta-percha in hard rubber.

This is not necessary with those who have had much experience, but with beginners it will be difficult to work up the gutta-percha as nicely as may be desired; a duplicate of vulcanite will enable the operator to make a more artistic model of the palate, and one which can be handled with greater freedom.

As in the course of a lifetime a considerable number of elastic palates will be required, the mold which produces them should be made of some durable material. The type-metal of commerce is admirably adapted to this use. The most complete mold is one made of four pieces, which will produce a palate

of one continuous piece. Such a mold requires very nice mechanical skill in fitting all the parts accurately, and unless the operator has had experience in such a direction, it is better to simplify the matter. By making the palate in two pieces, to be

FIG. 587.

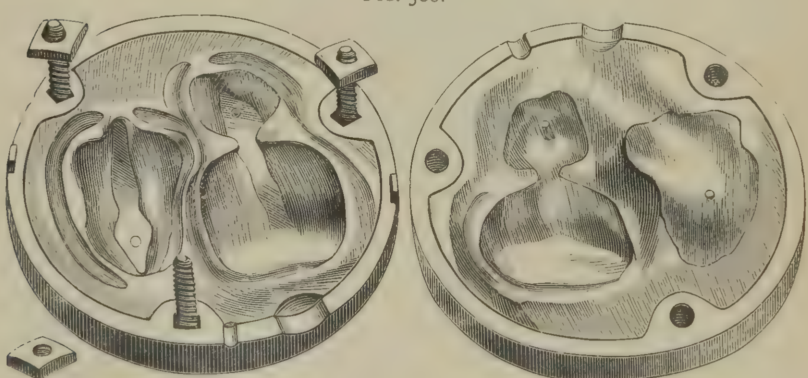


joined after vulcanizing, the mold may be made in two pieces, and with very little trouble.

Fig. 587 shows a palate divided.

Fig. 588 shows the mold or flask in which it is vulcanized. These flasks were made expressly for this purpose, but they are

FIG. 588.



not so unlike the flasks in common use in dentists' laboratories that the latter will not answer. The common flask is simply unnecessarily thick or deep.

The mold is readily produced in the following manner: Embed the two pieces of the palate in plaster, in one-half of the

flask; when the plaster is set and trimmed into form, duplicate it in type-metal by removing the palate, varnishing the surface, molding in sand, and casting. In making the sand mold, take a ring of sheet-iron of the same diameter of the flask and three or four inches high; slip it over the flask and pack full of sand. Separate them, remove the plaster, return the flask to the sand mold, and fill with the melted metal through a hole made in the side or bottom of the flask. With one-half thus made, substantially the same process will produce the counterpart.

Fig. 589 shows the palate complete with its attachment to the teeth. The palate is secured to the plate by a pin of gold passing through a hole in the palate of the same size; the head on the pin, being larger than the hole, is forced through, and thus the two halves of the palate are bound together and joined to the plate.

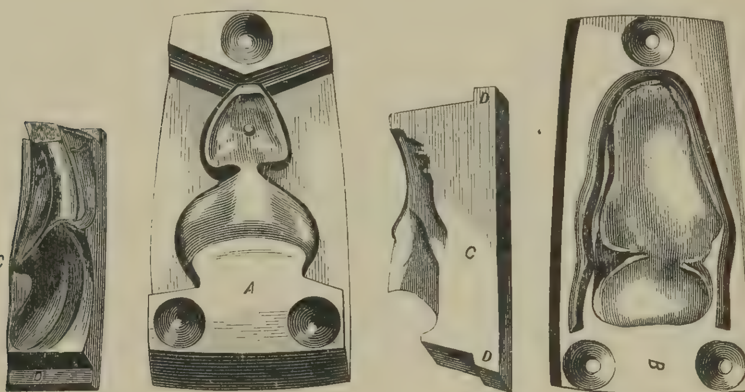
Fig. 589.

Fig. 590 shows a mold in four pieces. The blocks, C C, are accurately adapted to the body of the mold, marked A, and are prevented from coming improperly in contact with each other by the flanges, D D, which overlap the rest upon the sides of the main piece. B shows the top of the mold, and the groove, E, provides for the surplus rubber in packing.

Such a mold makes the most perfect appliance that can be produced. The palate is one homogeneous and inseparable piece. The cut will sufficiently indicate the forms of the several parts. Each of these pieces is first made in plaster of exactly the form of which the type-metal is desired. They are then molded in sand and the type-metal cast as in making an ordinary die for swaging. When in use, a clamp similar to Fig. 591 is placed around the mold to keep the several parts firm in their position.

The packing of the mold with rubber will be done in the same manner as when hard rubber is used for teeth bases, with which process it is assumed that the operator is familiar. By washing

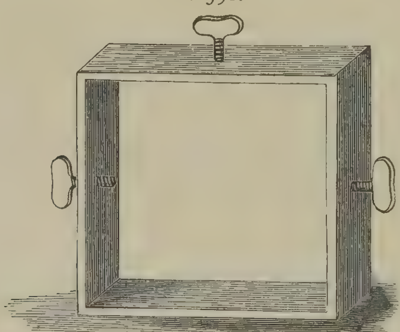
FIG. 590.



the surface of the mold with a thick solution of soap previous to packing, the palate will be more easily removed after vulcanizing.

The rubber used for this purpose must be a more elastic com-

FIG. 591.



pound than that used as a base for teeth. The composition used for the elastic fabrics of commerce will answer if made of selected materials.

Suersen's Obturator.—Dr. Wilhelm Suersen, of Berlin, intro-

duced an obturator the principle of which has seemed to many the best for obtaining correct articulation. In describing it (in *American Journal of Dental Science*) he says :—

" In order to be able to pronounce all letters distinctly, it is accordingly necessary (besides other conditions, which are far away from our present subject) to separate the cavity of the mouth from the cavity of the nose by means of muscular motion. That separation is, under normal conditions, effected, on the one hand, by the velum palati, which strains itself (consequently by the levator and tensor palati); but on the other hand, also, by a muscle which, to my knowledge, has, in connection with these operations, not yet received a sufficient amount of attention—I mean the constrictor pharyngeus superior. This muscle contracts itself during the utterance of every letter pronounced without a nasal sound, just as the levator palati does. The constrictor muscle contracts the cavum pharyngo-palatinum, the pharynx wall bulging out; and it is chiefly on the action of this muscle that I base the system of my artificial palates.

" These palates, which in all their parts are made of hard caoutchouc, consist of a teeth-plate suitably attached to existing teeth, and which, at the same time, covers the fissure in the hard palate (if such a fissure exists). Where the fissure commences in the velum, that plate terminates in an apophysis broad enough for filling up the defect. This apophysis is at the same time of such thickness as to keep up a contact between the high edges forming the sides of the apophysis and the two halves of the velum, even when the levator palati is in activity. To bring about this contact the more surely, the high edges forming the sides do not rise straight, but obliquely, toward the outside. The lower surface of the apophysis, turned toward the mouth, lies on about an equal level with the velum *if the latter is raised by the levator palati.* But when the velum hangs loosely downward the back part of the artificial palate is lying over it. This back part, accordingly, fills up the cavum pharyngo-palatinum, and in such a manner as not to impede the entrance of the air into the cavity of the nose when the constrictor pharyngeus superior is inactive. Thus the patient can without any impediment breathe through the nose. But as soon as the constrictor contracts the cavum

pharyngo-palati (this happens, as I will repeat for the sake of clearness, in the utterance of every letter with the exception of *m* and *n*) the muscle already named reclines against the vertical back surfaces of the obturator. By this operation the air-current is prevented from entering the cavity of the nose and is compelled to take its way through the mouth, and thus the utterance loses its nasal sound. To the existence of those vertical surfaces, and consequently to the thickness of that part of my palates which fills up the fissure in the soft palate and the cavum pharyngo-palatinum, I must attach special importance. But for that thickness the levator palati, when it rises upward, would not

FIG. 592.

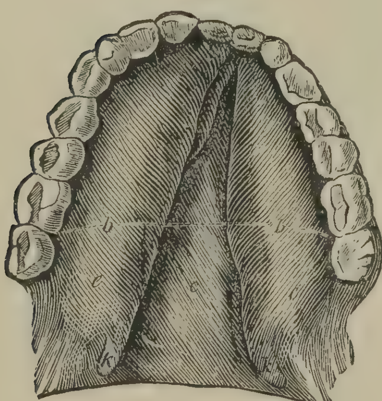
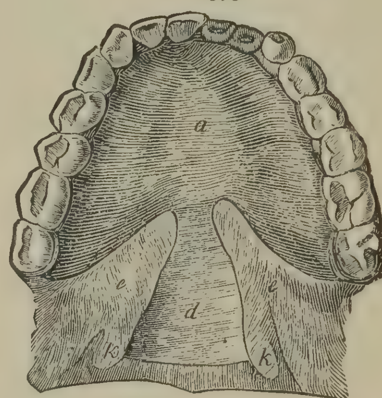


FIG. 593.



remain in contact with the side edges of the obturator, nor would the constrictor pharyngeus be able to effect a sufficient termination if the portion of the obturator nearest to it consisted only of a thin plate."

Fig. 592 represents the mouth without the apparatus.

Fig. 593 shows the apparatus in position; Figs. 594 and 595 give different views of the appliance.

Dr. Henry Baker, in writing of this appliance in the "American System of Dentistry," says:—

The plate, *a*, and its narrow and thin apophysis, *i*, which extends from the boundary, *b*, of the hard palate to the commencement of the defect, *c*, in the soft palate, serve also as supporters to

the real thick obturator, *d*. The latter lies in the pharyngo-palatine hollow, so that the lower surface of the obturator turned toward the mouth is about on the same level as the rest of the velum palati, *e*. Against the vertical side, *f*, and back edges, *g*, of the obturator the walls of the pharynx lean if the latter is contracted by a contraction of the superior constrictor of the pharynx. But if the muscle just mentioned is not in activity, the obturator does not touch the pharynx wall. The contraction of the constrictor superior therefore closes the valve formed, with the help of the obturator, between the cavity of the mouth and that of the nasal bone, while any relaxation of the abovementioned muscle immediately reopens that valve. The thick-

FIG. 594.

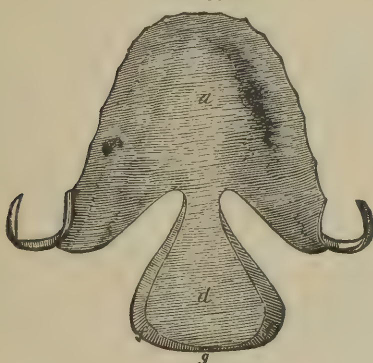
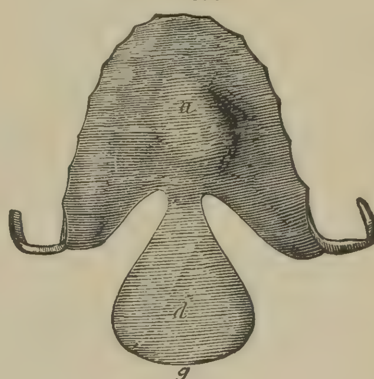


FIG. 595.



ness of the obturator begins where the fissure in the soft palate commences. With the high side edges, of the fore part of the thick obturator (which edges ascend, not straight, but obliquely, toward the outside), the side halves of the fissured velum palati, *e*, are in constant contact, even when the latter are raised by the action of the muscular levator palati. The proportions of the back part, which, in the same manner as in the case of an acquired defect, fill up the cavum pharyngo-palati, *k k*, are the two halves of the fissured uvula.

Dr. Suersen admits the importance of the part taken by the levator palati muscles in the formation of articulate speech; yet he makes no provision for utilizing them as such, and provides

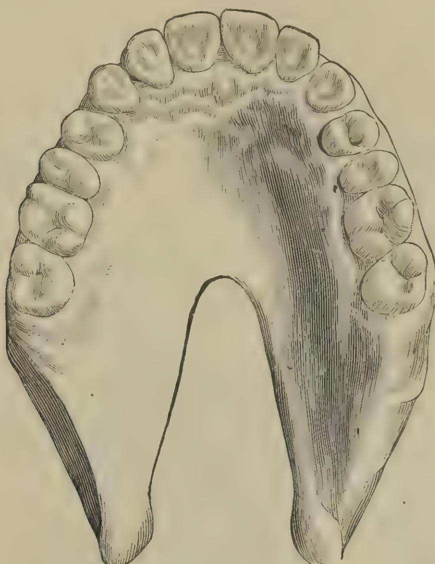
only for the contact of the superior constrictor muscle with the distal surface of the appliance to shut off the nasal passage. For the patient afflicted with congenital cleft to acquire perfect articulation with such an appliance (even if it be possible) years of application and training of this muscle would be necessary; and a little reflection will show that this muscle, besides performing its own functions, must be trained to fulfil those of the velum palati, levator palati, and tensor palati. But in an *accidental* lesion this may be all that is necessary, as the patient having previously learned to articulate distinctly, and having this deformity come upon him afterward, the superior constrictor muscle would no doubt be sufficiently developed to perform that function. Sir William Ferguson, in his report of a dissection made by him of a cleft palate in 1844, states distinctly that the constrictor was very full, and he also claimed for that muscle very decided forward action in deglutition.

Dr. Kingsley, in speaking of Suersen's appliance, says: "First, that of all obturators this is the best form for congenital fissure, but while the wearer is enabled to articulate with such an instrument, it is only after he has learned articulation with another apparatus. Second, that a soft, elastic, artificial velum is much better adapted to the acquirement of articulation than any unyielding, non-elastic substance, but when acquired an obturator may be substituted. Third, that in very rare cases articulation may be acquired with an obturator only, but it is the extra activity of the pharyngeal muscles, while with the elastic velum the levators of the palate contribute largely."

Baker's Velum.—Dr. Henry Baker describes his appliance as follows: "Numerous experiments to provide an artificial appliance with hard rubber, utilizing the levator muscles to control the movement of the appliance, and with which articulation could be learned as well as with the perishable soft-rubber velum, resulted in my adoption of the following device in cases where the cleft extends a little beyond the soft into the hard palate, as shown in Fig. 596. The appliance consists of a gold or hard rubber plate (A, Fig. 597), covering the roof of the mouth down to the junction of the hard and soft palates. From this point the movable portion, F, extends back and

downward, restoring symmetry of the palatal surface by bridging across and lying upon the muscles of each side. C E is a spring

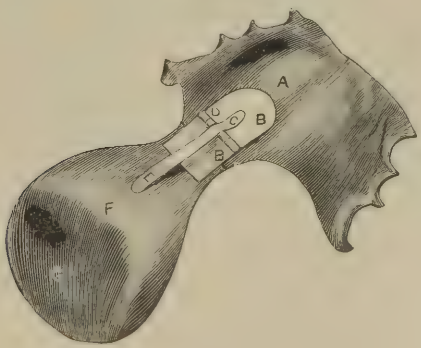
FIG. 596.



The Cleft, extending a little beyond the soft into the hard palate.

controlling the upward movement of F. The distal surface, G, or that portion coming in contact with the pharyngeal wall, is

FIG. 597.



quite broad, and so constructed as to articulate perfectly with this surface, while the constrictor muscle contracts and closes

around it on a semicircle. This is the Suersen principle, and the main ideas are taken from that appliance.

The velum is of polished hard rubber, gold, or platinum, and much resembles a chestnut in form.

It is attached to the plate with a hinge-joint, B, B, thus giving free movement at the junction of the hard and soft palates. At the junction of the hard and soft palates there is a stop, which prevents any downward pressure upon the muscles when in a relaxed condition.

FIG. 598.

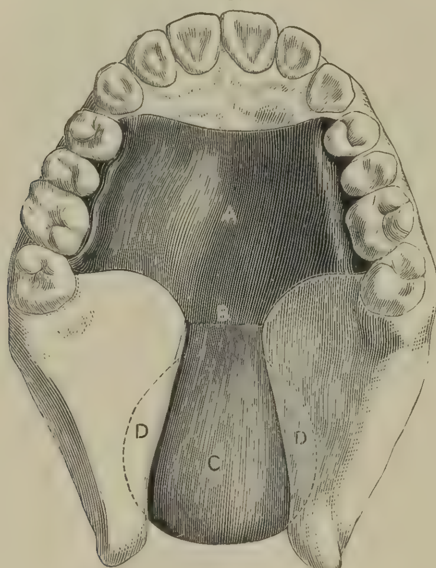
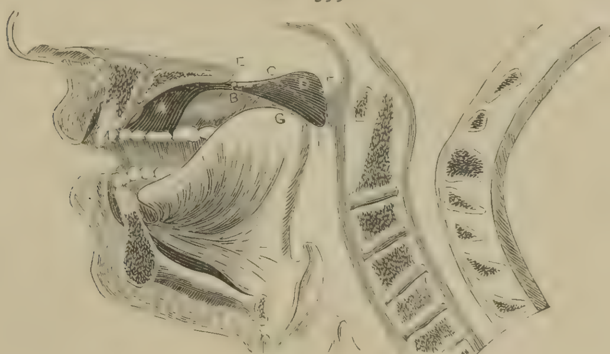


Fig. 598 shows the appliance in position, the dotted lines showing the part of the appliance resting on the muscles.

The main advantages of this appliance are—that it is made of a durable material, is easily constructed, and that articulation can be learned with it more readily than with any other appliance. In addition, it is so easily movable as to be acted upon by, and be under perfect control of, the muscles by which it is surrounded. In studying the mechanism of speech we learn that more than three-fourths of the sounds of articulate language depend upon the integrity of the soft palate for their

perfect enunciation. This being the fact, articulation with a rigid obturator must be extremely difficult to acquire. If three-fourths of the sounds depend on the free movement of the

FIG. 599.



natural palate, it seems a sufficient reason why provision should be made for the same movement in an artificial one.

Dr. Kingsley says that with a yielding appliance the levators

FIG. 600.

The muscles relaxed, the appliance descended, thus giving a free passage for nasal sounds and respiration.

of the palate contribute largely to correct speech. The surrounding muscles have control over the appliance here described in the following way: The artificial velum bridges across the

opening and lies upon the muscles of either side. (See Fig. 598, D, D.) With all sounds requiring the closure of the nasal passage it is thrown up by the levator muscles, as shown at D in the sectional Fig. 599, there being no resistance. The thickness of the velum brings its posterior surface in close apposition with the superior constrictor muscle, F, affording in the pronunciation of the gutturals a firmer resistance to the pressure of the tongue, G, than can be obtained with a thin obturator. By the presence of the hinge, B, the above movements are rendered so free and facile that there is no tendeney to displacement of the plate, such as occurs with a rigid appliance. If a nasal sound immediately follows a guttural, the descent of the velum is rendered certain by its own weight, even if not aided by the spring.

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